HEREDITY AND PARENTHOOD

BY

SAMUEL CHRISTIAN SCHMUCKER

Man's Life on Earth
The Meaning of Evolution
Heredity and Parenthood

HEREDITY AND PARENTHOOD

BY
SAMUEL CHRISTIAN SCHMUCKER, PH.D., SC.D.
EMERITUS PROFESSOR OF BIOLOGICAL SCIENCES
STATE TEACHER'S COLLEGE, WEST CHESTER, PA.

NEW YORK
THE MACMILLAN COMPANY
1929

Set up and printed.
Published, August, 1929.

Printed in the United States of America by
THE FERRIS PRINTING COMPANY, NEW YORK

INTRODUCTION

WHILE life will doubtless always be more or less of a mystery, modern science has disclosed many unsuspected leads into the maze. Enough has already been learned to vitally interest us, and to make further investigation both interesting and profitable. For a long time our ancestors felt that the mystery was one into which there was a certain impiety in intruding. Particularly the beginnings in the individual human life were avoided in conversation and in writing. This was due to a sense that it is immodest, if not shameless to inquire into these questions.

In these matters, as in so many others, the great growth of biology incident on a new viewpoint, has made an entire change in our attitude. The sense that man is the summit of the animal life of the earth (whether in plan or, as I believe, in actual blood relationship) has set us to studying the lower orders of the animal world. Here we see, in far simpler form, what in man is often very complex and the material difficult to get at. By killing and dissecting a number of one kind of any lower animal we can get a full series of the steps in any life process in which we are interested.

So guinea pig and rat, fruit fly and frog, peas and primroses have conspired to teach us to study our far more difficult selves. The results have proved unexpectedly interesting and valuable. On our study of heredity

we have based the new, and as yet very imperfectly developed practical science of Eugenics. This has had a powerful appeal, due in part, I fear, to the unwarranted claims of some of the less scientifically grounded of its devotees.

Processes involving the surgeons' knife and the animal breeder's tactics have been advocated until there has come, in the minds of many people, a revulsion against the whole science. This is unfortunate. There is much that is clear, definite, practicable and in no respect unworthy of our earnest attention.

It is the hope of the author of this book that he may be able to show to those untrained in biology, the exact evidence on which our knowledge is based. He also hopes to help in promulgating the sort of information that will be really helpful in the very slow, but by no means hopeless task of forming a favorable public opinion. With the growth of actual knowledge and of high aims man may really expect to help nature (is it irreverent to say help God?) in lifting human life to ever higher levels.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

PART I

HEREDITY

CHAPTER I

NATURE AND NURTURE

WHY are we what we are? There is scarcely any question that would seem more likely to interest the thinking mind than this, probing as it does into the very secret of our being. Anyone with wide experience may easily number among his acquaintances hundreds, and for some of us thousands of persons, and yet run no risk of confusing any two of them whom he has met reasonably often. There is a large additional number of whom he is convinced that, with a little closer acquaintance, they too would all become for him entirely distinct individualities. It is only in the case of certain twins that one ever despairs of learning to know two people apart. What is the force that gives to almost all of us two hands and five fingers, two eyes, two ears, two nostrils, one mouth—in other words so much that is alike and yet makes us different enough to give each a distinct individuality? This similarity is not inescapable. The dim shelves of the anatomical museums show bodies with two heads, heads with two bodies, heads with a single eye, or with nostrils and mouth a clover leaf shaped single opening. On the other hand, not infrequently, we find a pair of practically indistinguishable twins. The fact is, the process may go wrong either way. It may produce monstrosities that are horribly unlike us yet pitiably showing enough

likeness to be sure that they would have been people if somehow the course of development had not gone astray. On the other hand these mutually mistakable twins are often so marvelously alike that we cannot help believing that something unusual in the course of their development made them keep together.

In the course of my experience as a teacher I have come to know many pairs of twins. Two of such pairs stand markedly contrasted in my own mind.

In the one pair were a brother and sister. The boy was tall, slender, wiry, with straight black hair, long-headed, eager of disposition. His sister was of medium height, stocky of build, with curling brown hair, round-headed, placid of disposition. Yet these two were born of the same parents, in the same hour, reared on the same farm, eating the same food, meeting the same companions, taught in the same classes by the same teachers. Why the great difference between them?

On the other hand I have known another pair between whom I was always unable to distinguish. Their identity was sufficient to confuse many of their intimate friends. The similarity ran into astonishing details. It is quite as apparent in this case as in the other that something very unusual must have happened in the course of their development to keep these twins alike. What was it that kept the members of the first pair from being more alike? Why were the girls of the second couple so bewilderingly alike?

If we can answer this question quite clearly we are very close to an understanding of why we are what we are.

As to the characteristics which we possess, especially

if they be favorable, the popular assumption is prompt. They are "gifts." A person possessing such qualities is a "gifted" person. Sometimes, evidently referring to the parable of the talents told by Jesus to his disciple in that eventful last week, such a person is said to be "talented."

Our ancestors had an interesting way of accounting for these "gifts," especially in the case of people of importance. When we want to see what they thought on many questions we have a most interesting source in Grimm's "Household Tales." The brothers Grimm, who were eminent philologists, went to the firesides of humble German homes and listened to the tales with which the loving old grandmother delighted her grandchildren. These stories were not "made up," they were handed down. Doubtless the individuality of the narrator impressed itself somewhat on the story, but the whole framework reappears again and again. These stories reveal very much of the mythology of our ancestors.

In the tale of "The Sleeping Princess" we have our problem most interestingly answered. The queen has had every blessing in life except a child. At last, with marvelous antecedents, one appears. This child must of course have every advantage. So they invite to the "christening" (evidently a later modification) the "wise women" who are more than women who are wise, they are a sort of benevolent witches, with supernatural powers. There are thirteen of these in the kingdom. Unfortunately, there are only twelve golden dishes in the household equipment. The twelve nearest wise women are invited in the delusion that the thirteenth who lives in an obscure corner of the kingdom, will not hear of the slight.

After the child has been christened (baptized) the wise

women approach, one by one, and each endows the child with a separate "gift." One gives her beauty, another gentleness, a third goodness, and so it goes until eleven have so "gifted" the child. At this point the irate thirteenth having heard of the slight enters and decrees that the child shall prick her finger with a distaff on her fifteenth birthday and die of the wound. The twelfth, unable to avert entirely the bestowal of the thirteenth, decrees that the girl shall not die but sleep for a hundred years.

The balance of the lively story has nothing to do with our present problem. Evidently, however, our ancestors believed that outside superhuman personalities, seen or unseen, give us the gifts that make up our individualities.

Still farther back, and strangely persisting in odd and unexpected quarters, comes the notion that these things are due to "influences" that flow from the stars. We find interesting remnants in our language of times like this, as in our "Dog days," which are the days when the sun is passing through the constellation Canis Major, the bigger dog. In these days, so the belief of my childhood ran, if you go swimming you will get boils. I find no one avoiding shore or lake bathing on that account to-day. Still more amusingly reminiscent of the old beliefs is the observance of moon signs amongst certain of the rural population. Beets, potatoes, and such other vegetables must be planted in a "down sign" of the moon,—while corn, wheat, peas, young trees must be planted in an "up sign." Shingles too must be put on in a down sign or they will curl up after a while. Fence posts, if planted in an up sign will be lifted by frost when winter grows severe.

These simple beliefs however are quite overshadowed

by the deductions of the old astrologer who cast one's horoscope, judging by the "aspect" of the heavenly bodies at the hour of the birth not only the fortunes that would attend one, but the actual temperament of the individual.

The planet Mercury is a quick-circling body whose course about the sun is performed in a few months. Hence it is for but a little while in any particular part of the sky. Persons born under its exciting influence were naturally believed to be of uncertain quality, changeable and unsteady. A man born during its ascendance was one through whose mind flash brilliant plans which he begins with enthusiasm to carry out, and then shortly, wearies of the task and lays it aside. If the subject be a woman, a drawer somewhere holds pieces of fancy work one after the other of which was taken up and soon laid down again. These people are very happy when they are happy, but easily pass into just as marked depression. They are "mercurial" in temperament.

Next to Mercury passing out from the sun is the planet Venus. There is one part of its course in which it is relatively near the earth, and has much of its bright side turned toward us. Then it is quite the brightest and most beautiful object, after the sun and the moon, in the heavens. Naturally to this planet has been assigned the name of the queen of beauty and of love.

Should its tender influence be shed on the new-born child, our ancestors supposed a loving disposition sure to be the result. A man so dowered only needs a reasonable proximity to one of the opposite sex to fall in love, the process being more or less easily repeated with each renewed object with whom he is brought into moderately intimate contact. This temperament also had its name

which unfortunately, with the lapse of time, has been applied only to the evil side of this otherwise amiable disposition. The word "venereal" has come to be applied only to the most disgusting of the social infections which it is a travesty to connect with love.

The next planet in order passing out from the sun is the red planet Mars. Here the influence was supposed to be distinctly "baleful." One born under this star is by nature warlike. This, in time of war, finds a natural outlet. But often there is no war, yet this disposition must work out its result. There are people who walk about with a chip on the shoulder. Any slight difference of opinion is enough to start a vigorous controversy. Such persons were believed to be naturally quarrelsome, because of the "martial" influence of the ruddy planet.

Biggest of them all and always brighter than any other, except Venus at her best, is the planet Jupiter. It moves but slowly through the heavens, passing through about one constellation in a year. This planet was thought to have a "benign" influence on those whose birth its ascension views. People born under this "star" were supposed to be always of good disposition. Nothing sours them; nothing long depresses them. From beneath all the blows of fate they arise smiling. They see the sunny side of everything. In a word they are "jovial."

The ancients knew one other wandering star. It is much slower in its passage through the heavens. It takes about two and a half years to pass through a single constellation of the belt of twelve through which all the planets seem to move. Its brightness is about the same at all times and it is always distinctly duller and dingier than Jupiter. This is Saturn. People who are un-

fortunate enough to arrive on earth while this planet is climbing the heavens were thought to be doomed from the start. They are born with a grouch, grow up with a grouch, and die in the same unhappy frame of mind. They are sullen and sodden—they are "saturnine."

Shakespeare shows in his time that men already doubted the influence of the stars when in his play of Julius Caesar he makes Cassius say:

> "The fault, dear Brutus, is not in our stars
> But in ourselves that we are underlings."

But to this day any big city has people who, seriously or fraudulently, will cast the horoscope of any who are willing to pay the price—which should certainly be small.

Shakespeare with the wonderful breadth of mind with which he seemed to foresee and put into poetical form so much of the wisdom of the world, has given us a marvelous phrase. In that charming play of his late life, "The Tempest," he presents us with a hideous, half-human creature, Caliban. His master, Prospero speaking of Caliban says:

> "A devil, a born devil, on whose nature
> Nurture can never stick."

Of course what he means is that the wretch is so miserably bad in his very origin that no amount of training, of example, of education can make him anything better than he is.

Here is the whole modern idea in a particularly apt phrase—All we are, we are either by nature or by nurture. Either it was born in us, at least in its possibilities, or it

was developed in us as the result of influences from the outside. To put it into scientific language of the day, what we are, we are either by our heredity or from our environment.

People who think of such matters at all, and are not scientifically trained, believe, perhaps only half-consciously, that those of our peculiarities in which we differ strikingly from our companions are either the gifts, if good, or the visitations, if bad, of God; perhaps in this connection more likely to be named Providence. To these people such an answer cuts off all study and probably any hope of our understanding anything about the matter, since, as they have often heard, the ways of God are past finding out. They must be accepted on faith and let go at that.

To say to the scientist that God does it is to meet the rejoinder that the answer does not help him; it is not scientific. By this he does not mean that it is not true; it is not cast in scientific form or language. If he is both a "Christian and a scientist," his further statement will be—"Granted that God does it, the scientist wants to know how he does it. He sends the storm but this does not prevent our studying the barometer to see what He means to do next. It does not prevent our establishing weather stations all over the country in order that we may foretell His intentions for each section of the country and may publish them in the morning paper. Science is the study of God's method of doing things. When we know, or insofar as we know, how they are done, we know how He does them. So the scientist is not content to accept these human qualities simply as gifts or visitations; he wants to study how they come about; to foresee

how they will come about; to forward or to retard, perhaps even to prevent, their coming.

I suppose there is little doubt in the minds of most people, that in a general way, most of our qualities may be accounted for by inheritance. "He is a chip of the old block" is a common enough saying and belief. It is our peculiarities, our unexpected characteristics that must be explained.

A not uncommon way of accounting for blemishes and deformities is to credit them to impressions made on the expectant mother. Small red marks are said to be due to unsatisfied longings on the part of the mother. Usually these longings were for food—some red food—whose identity is shown by the shape of the "birthmark." Most commonly ham or strawberries seem to have been the objects of disappointed desire, and the thwarted longing wreaked its vengeance on the forming child and "marked" it from birth.

A larger and more diffused birthmark is usually said to be due to the fact that the mother was frightened by some conflagration in the neighborhood of her home.

Deformities are similarly thought to be produced by the fact that the mother, while still carrying her child within her body, saw unexpectedly some person similarly deformed.

The attitude of both biologist and well-trained obstetrician is now at one on this matter. There is no basis for a belief in "prenatal impressions." The mother can neither malform her offspring, except by mechanical accident, nor can she foster its favorable formation into any predetermined shape by rapt contemplation of a beautiful painting or statue or other human being. She can

be a wholesome or an unwholesome nest and nurse, and that alone.

The biologist is repeatedly asked, in how far are we what we are as a result of heredity and what part of our nature is due to our environment. Occasionally the confidence in the scientist's ability to furnish an accurate answer is great enough to give the question the form "What percent of our qualities come to us from heredity and what from environment?"

Of course, in the mind of the questioner, the conviction is clear that, the sum of the two answers must be one hundred. But such a division is impossible. Whatever we are is due to both heredity and to environment. Every possibility is ours through inheritance. In how far such a possibility shall come to development may be determined very largely by environment.

It must never be forgotten that, in the tremendously great majority of instances, our characteristics are due absolutely to heredity. We are so, or we are not at all. No environment can make me grow up into anything but an animal, rather than a plant; a vertebrate not an insect; a mammal not a fish; a primate not a carnivore; a man not an ape; a white man not a black. The number of my limbs, my digits, my eyes is fixed. I will have hair on my head.

This backbone may become misshapen by accident of environment, my fingers may be clumsy or skillful by training, my eyes may be acute, or blunted by misuse, my hair may be lustrous and brown or whitened by age or even by worry. But the fact remains, there is an overwhelming series of details in which I am like every other white human being, and these I owe absolutely to my

heredity. No environment, except in many generations and long ages will change them in any perceptible degree.

The food I eat passes through the same organs, which act on it in about the same way as in any other human being.

The blood that flows through my body follows the same general course it does in my fellow mortals.

Unexpected noise makes me start; the sudden appearance of a large and not well-known object momentarily freezes me into rigidity as it does any of my companions.

All of this is hereditary. Much of this may be modified by environment. Worry or weariness may make my food pass undigested through my canal. The amputation of a part of my hand may bring about the development of new courses for the blood in adjacent parts. I may in time hear the same noise so often that instead of starting I may fail to notice it at all. I may learn to walk imperturbably across a thoroughfare where streams of rapidly moving automobiles cross each other at various angles. All this modification environment may make in my native endowment. But the part changed by environment is pitiably small compared with the great mass of characters in which I am almost exactly like every other human being.

For many years the sociologist and the hygienist have been at work improving the human environment. The result of their work is blessed. They have lengthened human life; they have made it infinitely happier. This work is well worth while. It must never be abated. Here indeed is its difficulty—it must never be abated. It must be repeated with each generation.

But the student of Eugenics has a high hope. If by

any means he can produce a real improvement in the human stock, such as, at least in certain lines, he has produced in his favorite domesticated animals, the result of his work may extend through many generations. If by any worthy means (and notice please that word worthy), he can increase the proportion of fine strong beautiful upright human families and diminish the ratio of shiftless, weak, defaced, unmoral people, then the world will be bettered for ages.

So there is room for both eugenics, and euthenics, for the scientific knowledge that would improve the stock and that which would better the surroundings in which that stock must grow up. There is no danger that either of them will ever run out of work. There is no limit to human perfectability. There is enough perfectly certain knowledge now on both sides of the problem to make human life a far finer thing than it now is, could the mass of people but be persuaded of the truth of what the scientist knows and to act on it.

Day by day, little by little, prejudice is being overcome, the inertia of ignorance is being broken. That much greater activity is to come in the not distant future who can doubt?

CHAPTER II

A MONK AND HIS PEAS

THE human mind is like the human eye; it can closely attend to but one thing at a time. In the very center of the retina of the eye is the yellow spot. Here the tips of the rods and cones which form the ends of the filaments of the optic nerve are most crowded and quite most easy of access. Any object whose image falls on that yellow spot commands our attention to the exclusion of everything else. Other things may be dimly seen, and if for any reason such an other is particularly striking—is highly colored or moves quickly or catches and reflects the sunlight—it may "catch the eye." We turn our heads or our eyeballs or both and fix them so that the attractive object sheds its image directly on the yellow spot. Then this new object holds the attention and all else fades.

Very much the same state of affairs holds concerning the human mind. It can run easily from one thing to another, as does the eye. But whenever any one object or event holds the attention, all else temporarily fades into indistinctness.

When the world war was on, it was so overwhelmingly the most important event transpiring that naturally it claimed our almost undivided attention. So we talked war, and we planned with reference to the war, and we read about the war; and everything else received scant

attention. Our papers brought us war news, our magazines discussed, pro and con, every sort of detail of plan or hope or aim or even guess—and all were avidly read.

But it does not need anything so tremendously affecting us all, to make us turn our thoughts into a common channel.

An American youth, of force, training, and intrepid courage, without preliminary flourish, or apparent desire to call attention to what he is doing, leaps up from America into the sky. He faces the dark, the cold, the fog alone, unaided; without advice or counsel in emergency, he meets and vanquishes every obstacle. He crosses the great ocean, and lands temporarily near the spot at which he aims. A few minutes to get his bearings and make his adjustments, and away he leaps and comes down just on the spot for which he sailed and almost on the hour at which he expected to land.

And now the crowd, that had gathered in expectation of his coming grows wild. The men lift him on their shoulders and carry him in triumph. Within a few hours all the world knows his name. Towns are named for him, babies will be dated for all their lives by the name they bear. Hats, and ties and all sorts of clothing carry the same enticing cognomen.

For a week the papers carry little else—we are all thinking of the one unforgettable youth.

So during the third quarter of the nineteenth century the mind of the scientific, indeed of much of the learned, world was turned on one all absorbing topic. One question was always before it—the so called "species question."

A young man, fond of outdoor life, a collector of

beetles, the pupil of a botanist and of a geologist to whose indoor lectures he paid scant attention but on whose field excursions he was their constant companion, had found a great opportunity. He was appointed naturalist to accompany a sailing expedition which was particularly to chart the coast of the southern portion of South America and to redetermine with new exactness the longitude of a chain of ports stretching around the world. Charles Darwin was afloat on the "Beagle." In the course of that voyage they touched at Peru. Here he had a chance, indeed it was his duty, to study the animals and plants of the neighborhood. He paid much attention to the lizards, the sparrows, the grasshoppers of this western coast.

Then the ship turned its prow westward for its long sail across the Pacific. Before they had gone more than a few hundred miles they struck a group of about a dozen rocky islands. These were famous for the enormous turtles who lived there. These turtles weighed about two hundred pounds or more when well grown, and were reputed to have lived long enough that if they had gained but a pound a year they would have their present weight. These turtles gave the name to the islands, for Galapagos in the Portugese language is said to mean turtle.

The animals of these islands were carefully studied by young Darwin. Particularly the "finches" (sparrows) claimed his attention but also the lizards and the grasshoppers.

It was not long before he realized that each island had animals of its own—not quite like those of any other of the islands, and all of them somewhat, though not exactly, like those of Peru.

After the party had left the islands, and were sailing, through wearisome weeks, across the almost unbroken ocean, Charles Darwin had abundant time to study his specimens gathered on the Galapagos group.

He had set down at the end of the chapter in his Journal describing their stay on the islands a most interesting reflection. "It would seem," says he, "as if this little group of rocky islands had been one of the greatest centers of creative activity."

Unconsciously he spoke, as anyone else would then have spoken, as if the Creator had specially designed a species of finch, or lizard, or grasshopper for each of these little islands.

When he came, however, to study these animals slowly and carefully, he realized that the nearer two islands were to each other, the stronger was the likeness between the animals found on these islands. If the animals came from islands remote from each other in the group they were much less like each other than each of them were to those of the intervening islands. Practically all of them, however, differed, more from the animals of Peru than they did from each other. Slowly he came to the conclusion that these creatures all had a common origin. They had all descended from ancestors who came from Peru, borne by some accident of storm or floating on logs or other débris. When they got out here those of each kind were all alike. But, separated from each other, the inhabitants of the various islands were more or less cut off from communication from, and particularly from interbreeding with, each other. Each island developed its own slowly altering population. Here then was the first really striking extended series of observations that had convinced

the naturalist he had to do with "descent with modification." When, several years later Charles Darwin reached home, it was with the clear conviction in his own mind, that the animals of to-day are the altered animals of yesterday; that similarity is evidence of common ancestry.

But why had they altered? This was to him then a challenging problem. The hint of a solution came when he considered the many varieties of domesticated animals and cultivated plants. Perhaps amongst the animal world the pigeons and the chickens drew his attention more fully. In plants a wide range rewarded his efforts—primroses, salvias, beans and many others. It was his profound conviction that if he could discover how new varieties arose, under the hand of man he would have the key to the "Origin of Species" at the hand of the Creator.

He began collecting all the breeders' magazines he could lay hold of. He found the key to the new forms in "selection." A breeder found a small variation, which he liked, amongst his plants. He separated it from the rest, fertilized it from itself or from another just like it. He kept the progeny from mixing with others in the next generation but bred within the group, weeding out carefully any that did not show the desired trait. In time he "fixed" the variation on his new race of roses or carnations or peas or gooseberries and had a new variety produced by "selection."

After years of working a fruitful suggestion came from reading Malthus "On Population." It was the claim of this author that man multiplied more rapidly than his food supply and that it is only a question of time when there will be too many people on the earth for com-

fortable support. He believed this time would long since have been reached but for the natural checks of war, pestilence and local famine. With increasing civilization the effect of all of these was being greatly lessened and the time was not far distant when the population would overrun the food supply. His remedy was such "self restraint" as would diminish the number of offspring in each family. It is on this account that modern advocaters of limiting the family by artificial means, that is by "Birth Control," are often called "Neo-Malthusians."

Darwin found in this quick rate of multiplication, far more rapid amongst lower animals than with man, the secret of his problem. Too many animals are born to live. Most of them must die. It is not a matter of accident which die first. There is much small variation amongst offspring even of the same parents. Those best fitted to cope with the surroundings live the longest. Those least fitted to bear cold or hunger, or to escape the attention of their enemies or to fight them when they had been discovered, passed out first. This left a superior portion which grew larger and more pronounced as time went on. This process Darwin called "Natural Selection." It was this idea, advocated in his paper read before the Linnean Society in 1859, and in his book on "The Origin of Species by Means of Natural Selection" published a little later, which stirred the intellectual world of England and soon of the continent as it had not been stirred for a long time.

Darwin's contribution to the thought of his time, was double. He persuaded the scientific world, and gradually much of the thinking world, of the fact that the animals and plants of to-day are the altered animals and plants of

yesterday. On this the biological world is in overwhelming majority, quite agreed. In addition, Darwin suggested a process, "Natural Selection," which he believed to have been the chief agency in bringing about the change. It is this idea which is known as Darwinism. When a modern biologist says he is not a Darwinian he does not mean that he does not believe in evolution. Almost always he does so believe. What he means is that he does not think the process of Natural Selection is capable, at least working alone, of effecting the change. Darwin himself stated that he took variation for granted, and—as he found them—abundant, and he believed largely "spontaneous."

Here is the problem of the modern student of Heredity. Why do children resemble their parents? If so resembling why do they not exactly resemble them, and why do children of the same parents, born at the same time, differ? Darwin's publication set the biological and the theological worlds into a ferment. Many clergymen of the Church of England (to which by the way Darwin belonged, and which he steadily attended when his health permitted) were students of "Natural History," and were thoroughly interested in this new problem. It was this absorbing interest in the species question which kept men then from noticing a most remarkable paper which appeared in the Journal of a small Natural History Society in Austria, written by a Monk, and detailing his "Experiments with Hybrids." This paper is to-day the foundation of all our work on Heredity. The principles there enunciated have stood the test remarkably, and later workers have extended these researches in every direction. But they all go back to Mendel and find in that

name one that may in time stand beside that of Charles Darwin, "The Father of Modern Biology."

In the portion of Austria which has now become Czechoslovakia is the town of Brünn. It nestles amongst the hills and is the seat of a considerable textile industry, as it has been for a long time. On the edge of this town is a monastery. Attached to it there was, doubtless still is, a garden. Here the pious and industrious monks raise much of the vegetable food that finds its way to the table of the monastery. It seems a humble task to be gardener in such a quiet spot. But to those whose lives are devoted to the service of God with the single-mindedness of the monk no task is either humble or exalted beyond another. Each is the rendering of service to God. So the brightest mind may find itself set to what seems the humblest task, and his devotion exalts the work. Certainly it was so with the monk, Gregor Mendel.

This man was a member of the Natural History Society of Brünn and was interested in botany. So while he cultivated his garden he cultivated his higher faculties as well by studying the plants with which he worked. His inquiring mind became interested in the problem of the results of crossing two different strains of plants. In pursuance of this aim, he devised a series of experiments the final report of which has made the name of Gregor Mendel immortal.

His first step was to get hold of a set of "pure strains." He sent to each of the great seed merchants of Europe, buying a small quantity of each kind of peas he had for sale. Registering and recording a number for each parcel he followed carefully the history of that batch of peas.

He cut up a part of his ground into small plots, in

each of which, carefully marked, he planted one of the packages of seed. He watched these peas spring up. If some of them came more quickly than the great mass, or delayed longer than their fellows, he decided from this fact that it was a "mixed" strain. If some of them grew much taller than others it was mixed. If the blossoms differed in their time of arrival or in color or form it was mixed. All such mixed strains might be used for food, but they were rejected from the experiment.

When however he found a group of peas which, when planted, all came up in about the same time, all grew to about the same height, all bloomed at about the same time, all showed the same shape of blossoms, all formed pods of the same form at about the same time, and all showed the same color and rotundity of peas in the pod, he knew he had a pure strain, within the meaning of his experiment.

Now came the stroke of genius which put definiteness and point into his experiment and made it the starting point of hundreds like it in later hands.

He found two strains of peas which were as nearly alike as possible in every respect but one, and in this respect were sharply different.

The first pair of contrasting characters he used was the matter of height. As everyone who has done even amateur gardening knows, there are bush peas and brush peas. Bush peas grow about a foot or a foot and a half high, and have stems quite strong enough to support themselves very nicely.

Brush peas grow several feet high. They need brush or stakes or wire frames or strings to support them. Here then is a pair of clearly marked characters in peas

which can be easily noticed and recorded. So his earliest experiments were made on "tall" and "short" peas.

In carrying out his experiment he planted a patch of pure-bred short peas in one place and nearby another patch of tall peas. In all other respects these peas were alike. He had here but a single pair of contrasted characters with which to work.

When these pea plants blossomed he took pollen from the blossoms of the tall plants and put it on the pistil of the blossoms of the short plants. By this procedure he saw to it that the peas which later formed in the matured ovary (pod) of a short pea had a tall pea plant for its father and a short pea plant for its mother.

I may here pause to say that he later found that the direction of the cross made no difference whatever. The result was exactly the same, whether the cross was between a tall father and a short mother or between a short father and a tall mother pea plant.

When these tall and short plants were thus crossed he was interested to find that every pea plant grown from the peas resulting from this cross was just like every other, with respect to tallness. In every case the peas were tall, as tall as the tall father. So far as any outward appearance was concerned, both parents might as well have been tall. There would have been no difference in the result so far as this generation showed. These new pea plants looked just like their tall father and so far showed no trace of their short mother.

But when these plants came into blooming and he crossed them with each other the result was most striking. About three fourths of all the plants that resulted from planting peas formed on these tall plants were as tall as

the original tall grandfather and one fourth were short, as short as the short grandmother. It was plain that while these second generation pea plants (or as Mendel called them, first filial generation) only showed the influence, so far as size is concerned, of their tall father, they had at least in part, the power of handing shortness to the next generation. It later proved, every one of this first filial generation was alike in this respect.

When the three tall (to one short) of this generation were further crossed they proved not all to be alike in their power to transmit stature. One out of three tall ones (on the average), if fertilized by itself (which is quite possible and indeed common in peas) gave only tall pea plants. There was no shortness in it. The two other of each three talls (again on the average) if crossed with themselves or with each other, behaved just like the crosses in the first filial generation; they produced three tall plants for every short. Of these last three talls, only one carried pure tallness, while the other two carried both tallness and shortness. The short one never carried anything but shortness.

To recapitulate this process, when a tall parent (in these peas) is crossed with a short parent (these two being known as the parental generation) all the progeny are tall. If we cross these of the first filial generation, we get three talls and a short, of which three talls, one is pure tall and the other two are tall-short (though they look tall) while the short member is pure short.

It is evident that where any pea plant of this kind has both shortness and tallness in its transmitting power, the shortness does not show.

Hence Mendel called tallness in these peas *dominant*

and shortness *recessive* and these two terms have lived since his time and are in constant use to-day by students of heredity.

What really happens is this. A pure tall pea plant has tallness from both sides. Let us call it tall-tall. The short pea plant is short from both parents; it is short-short. Now in this tall-tall father either tallness, but not both at the same time, can mate with either shortness of the mother, but not with both at the same time.

Hence let us say that in the pure tall parent there is paternal tallness, inherited from his father and maternal tallness inherited from his mother. Let us also say that in the short pea plant there is paternal shortness inherited from her father and maternal shortness inherited from her mother.

As at any one crossing of peas of these stature influences, only one from each side can join, there are evidently four possible combinations. Paternal tallness with paternal shortness, paternal tallness with maternal shortness, maternal tallness with paternal shortness and maternal tallness with maternal shortness.

Every one of these however, results in a tall-short combination. It matters not which grandparent or which parent contributed either half of this combination. All tall-short combinations of these peas are alike.

Hence the result of crossing a pure tall pea with a pure short pea is to produce only tall-short peas which look like tall peas but can transmit both tallness and shortness.

If then any member of this first filial generation of hybrids was either self fertilized or crossed with one of its sister stalks, the result was that on the average, of all the peas produced, there would be three times as many

talls as shorts and of these tall plants one third would be pure tall, and the other two thirds would be tall-short hybrids that looked just as tall as the pure tall members of this the so-called second filial generation. The shorts are always pure short.

The fact that in this second filial generation the pure tall was just as pure in every way as its tall grandparent, and the short was as pure as its short grandparent, Mendel characterized as "segregation." He believed—rightly we still think—that tallness and shortness were paired unit characters and that each of these characters went into and out of combination entirely independently of any other characters.

The following diagram indicates what happens, the dominant tallness being indicated by a D and the recessive shortness being indicated by an r.

Parental generation, crossed in the four possible ways, produces $\left\{\begin{matrix} D \text{———} r \\ D \text{———} r \end{matrix}\right\}$

First filial generation $\left\{\begin{matrix} D \\ r \end{matrix}\right. \quad \left\{\begin{matrix} D \\ r \end{matrix}\right. \quad \left\{\begin{matrix} D \\ r \end{matrix}\right. \quad \left\{\begin{matrix} D \\ r \end{matrix}\right.$

Any two of these crossed give

Second filial generation in four possible forms $\left\{\begin{matrix} D \\ D \end{matrix}\right. \quad \left\{\begin{matrix} D \\ r \end{matrix}\right. \quad \left\{\begin{matrix} r \\ D \end{matrix}\right. \quad \left\{\begin{matrix} r \\ r \end{matrix}\right.$

Of these four, the first, crossed with itself, with its dominant grandparent or with any other of its own kind, gives $\left\{\begin{matrix} D \text{——} D \\ D \text{——} D \end{matrix}\right\}$

$\left\{\begin{matrix} D \\ D \end{matrix}\right. \quad \left\{\begin{matrix} D \\ D \end{matrix}\right. \quad \left\{\begin{matrix} D \\ D \end{matrix}\right. \quad \left\{\begin{matrix} D \\ D \end{matrix}\right.$

The second and third, crossed each with itself, or with each other, or with any other of their kind, including their parents, will give

$$\left\{\begin{matrix} D & & D \\ r & & r \end{matrix}\right\}$$

$$\left\{\begin{matrix} D \\ D \end{matrix}\right. \quad \left\{\begin{matrix} D \\ r \end{matrix}\right. \qquad \left\{\begin{matrix} r \\ D \end{matrix}\right. \quad \left\{\begin{matrix} r \\ r \end{matrix}\right.$$

The fourth, crossed with itself, with its recessive grandparent or with any other of its kind, produces

$$\left\{\begin{matrix} r & & r \\ r & & r \end{matrix}\right\}$$

$$\left\{\begin{matrix} r \\ r \end{matrix}\right. \quad \left\{\begin{matrix} r \\ r \end{matrix}\right. \qquad \left\{\begin{matrix} r \\ r \end{matrix}\right. \quad \left\{\begin{matrix} r \\ r \end{matrix}\right.$$

Following a similar course of procedure, he selected another group of opposed unit characters. He found that some peas get yellow when they ripen while others no matter how long they mature retain their green coloring. He crossed these and found that the first filial generation was always yellow while in the second filial generation there were three yellows to a green and that of these three yellows one was a pure yellow and the other a yellow green hybrid, while the green was pure green. In this case it was yellowness that was dominant.

In still another set he found it possible to cross pea plants, one kind of which had peas that fattened as they ripened while the other parent bore peas that no matter how thoroughly they ripened always remained wrinkled. Here again he obtained results exactly similar to the two preceding except that here it was fatness that was dominant and wrinkledness that was recessive. Crossing the two contrasted parents, fat and wrinkled, he found his first filial generation all fat. In the second filial generation he found three fat peas to one wrinkled.

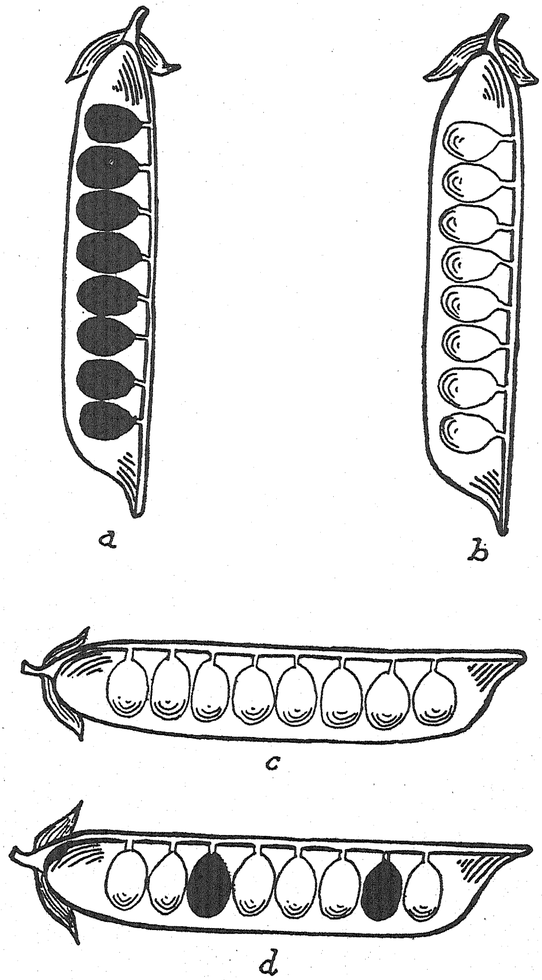


FIG. 1—Green and yellow peas, crossed. *a*—The pure green male parent; *b*—The pure yellow female parent; *c*—The result of the cross, all yellow; *d*—The result of crossing two peas from *c*, three yellow for each green. Yellow is here dominant.

Of the three fat peas one was pure fat and two were fat-wrinkled hybrids while the fourth was pure wrinkled.

For simplicity I have spoken in each case as if there were four peas in each set of pea children. Of course there were many more. If there were only four the chances of their coming out like this were very small. It was only when he took large numbers and averaged them that he got these results.

For instance, in the matter of tallness and shortness in the second filial generation, instead of finding exactly one to three, Mendel found 787 to 277. This is not quite three to one, it is as 2.83 to 1.

In the case of yellow and green in the second filial generation Mendel found 6,022 yellow to 2,001 green which is as 3.009 to 1.

In the case of the fat-wrinkled set he found, in the second filial generation 5,474 fat to 1,850 wrinkled which is as 2.958 to 1.

These results were so nearly like three to one that there could be no possible doubt as to the underlying law.

Darbishire, an English investigator, carried the yellow-green so far as to get 109,060 yellows to 36,186 greens, which is as 3.011 to 1.

Mendel then tried crossing pea plants which were similar in all but two pairs of contrasted characters. Here he got results based entirely on the same principle as those reached when he had one pair. When he took round yellow peas and crossed them with wrinkled green there were these results.

Out of each sixteen peas on the average we find: of the fat-yellow 9, of the fat-green 3, of the wrinkled yel-

low 3, and of the wrinkled green 1. That is, there are 12 fat peas to 4 wrinkled, and 12 yellow to 4 green. Thus we find three times as many of each dominant as of its corresponding recessive. This 9:3:3:1 ratio is found only where there are combinations of two sets of paired characters.

Later Mendel tried the same sort of experiments with an entirely different plant, a St. John's Wort; but his results were of exactly the same nature.

Then he was promoted to be the head of the monastery, and his duties in that connection made it impossible to continue his researches. His results were published in the Proceedings of the Natural History Society of Brünn, Volume IV, 1865. Unfortunately the circulation of this periodical was not large and in the face of the deep interest then being shown in the Evolution researches the paper seems to have escaped, almost entirely, the attention of active workers.

Charles Darwin had believed that the alteration of one species into another was usually by gradations so small as to be, in any one generation, practically imperceptible.

Hugo de Vries of Amsterdam found in his garden some evening primroses (*Oenothera Lamarkiana*) which gave many new forms, apparently spontaneously, and these forms persisted in later generations. These somewhat abrupt changes de Vries called mutations and believed them, rather than the small progressive changes of Darwin, the factors in evolution. Looking over the literature of his subject de Vries in 1900 discovered and called public attention to this paper of Mendel's and expressed his sense of its importance. By a strange coincidence two other workers, Correns and Tschermak, each indepen-

dently of the other, also found and noticed this paper in the same year.

Mendel had been dead for many years. Perhaps he himself never realized the importance of his paper. If he did, it must have taken all his pious devotion to have suppressed his disappointment at the lack of appreciation on the part of the scientific world.

In 1902 Professor Bateson of Cambridge University, in England, published a book called "Mendel's Principles of Heredity" in which he gives a translation into English of Mendel's original paper together with an explanation and an expression of his sense of its importance. This made the whole subject at once familiar to the scientific world.

Later work has entirely confirmed Mendel's observations, in very many fields, and extended them much farther than Mendel did. There is no doubt in the mind of any present working biologist of the validity of Mendel's law. The only question is as to whether there is any other type of inheritance. Many facts that seemed at first to run counter to this law have when better known confirmed it. The difficulty, where there is one, usually comes from imperfect dominance or from the fact that what was supposed to be a unit character proves to be a combination of three or four, any one of which enters and leaves combination independently of the others. This produces a confusing variety of forms; but eventually they are all found to be in conformity with the law.

Mendel's name runs no risk now of ever dying out. It will always be one of the great names in biology.

CHAPTER III

THE STREAM OF LIFE

WHILE Gregor Mendel was quietly working in his monastery garden with his revealing peas and finding his laws; in another part of Europe another side of the problem was quite unexpectedly working itself out.

The life of August Weismann was one of those quiet, apparently uneventful existences which, to the casual observer, would seem to be not only without incident but even without significance. It was a life spent largely within the walls of universities, first as student later as teacher, and always as investigator.

As was true of many early biologists, his entrance was through the pathway of medicine. It was his intention to practice that profession, but his success as a teacher and an investigator was such that he was able to devote his life to this side of the work he loved so well.

Beginning his medical course at Goettingen under Rostock, he went successively to Vienna, Italy, and Paris. He closed his course at Geissen under Leukart, then one of the best microscopists in Europe, and a devoted student of animals that live as parasites on or in other animals, usually to their detriment, sometimes, to their destruction.

The insects proved a most interesting group to young

Weismann as they have to many another investigator. These animals are so numerous and so diverse that the student must make choice of one group and Weismann chose the one which embraces the flies, mosquitos, gnats, and their allies. Even this was too big.

One of the most interesting aspects of the life of any animal is the way in which it produces its young and provides for their nourishment. These young in the case of the great majority of insects, the parent never sees.

So we find one of the earliest serious pieces of work undertaken by Weismann was "The Development of the Diptera." Doubtless his work with Leukart led to a deepened interest in those flies that are parasitic. In any event it was his investigations into the life history of the sheep warble fly that led him to his most profound discoveries. There is a fly that lights on the back of a sheep, punctures its skin with its ovipositor (which is the sting of the bees) and places an egg in the hole thus formed. This egg soon hatches and a "warble" or fat maggot, emerging from the egg shell, grows in a cavity it makes for itself in the skin of the sheep. When this maggot is full grown, it passes into a quiet stage during which its organs are reformed to suit it to the life of a fly. This process completed, it makes its way out of the skin of the sheep, leaving behind it a cavity in the skin which much reduces its commercial value.

The presence of the sheep warble in the neighborhood set Weisman at work studying intensively its life history in order to find how to prevent its ravages.

To the study of this life history our young professor

devoted himself with remarkable patience and persistence He soon became an adept in three processes which have made modern microscopy so fertile in results. It may not be uninteresting to detail these processes, in order to give us a better understanding of the very important results gained by their use.

The microscope has been about what it is to-day for at least half a century. If there is any real difference it lies in the fact that it is simpler to-day than it was earlier. The great developments of the last fifty years in biology have been made possible by improvements in the method of preparing objects for examination under the microscope.

The "field" of the microscope is purely two dimensional. The view shows the length and width of an object, but gives it no thickness. The skilled microscopist can give himself some idea of the third dimension by placing a finger on the fine adjustment and running the microscope up and down. Thus he gets two dimensions with his eye and "feels" the third with his finger. But the common method now with a comparatively large object is to cut it into very thin slices for examination.

Weismann was anxious to know the structure and behavior of the very cells of which living bodies are made. To slice them for examination is of course to kill them, and by the time these cells were ready for the microscope, in the earlier day, they were so altered that one had little idea of their character when alive.

Hence the first process in their preparation consists in killing them, with such suddenness and thoroughness that the contents of the cells are both killed and preserved so instantaneously that there is no time for alteration.

There are various ways of accomplishing this. The description of one will serve to explain them all.

Let us take as an illustration a possible procedure in preparing the larva of a mosquito, the so called "wriggler" of the rain barrel or small pool.

Into a slender glass vessel known as a test tube is placed a little solution of corrosive sublimate (bichloride of mercury) one of our strongest and most deadly poisons. This is to promptly kill the wriggler. To this is added some absolute alcohol which will preserve him. Then a little sulphuric acid to make the solution penetrative and to prevent the alcohol from shriveling the object. These fluids mixed in proper proportions, are heated in the test tube over a lamp flame. The wriggler is placed alive in a small watch glass, and the hot solution just described is quickly poured over him. It is so deadly and so penetrating that we have good reason to believe no part of the cell has time to alter its formation, and the dead tissue represents exactly the structure of the cells at the instant before death. This process is called "fixing" and an animal so treated is certainly fixed.

The next procedure is to cut the animal into slices. Here again the microscopist has come to work with the utmost nicety. He washes the fixing solution out of the fixed larva with water. This does not unfix the wriggler, it only gets rid of the fixing fluid which would hamper later processes. This washing accomplished, we must get rid of the water. So the object is immersed in water containing thirty per cent of alcohol for a number of hours. From this is goes into a sixty per cent, then into a ninety per cent solution of alcohol in water. Finally

it is passed into absolute (pure) alcohol. By this process all the water has been removed.

Now the object is "cleared," that is made transparent, by immersing in, any one of a number of fluids, let us say for example, turpentine.

A short digression will make the next steps more clear. Suppose I were to take a fish to the ice plant and have it thoroughly frozen in the midst of a cake of ice. If then I were to saw the ice in slices an inch thick, each slice would contain one "section" of the fish. If the slices were laid side by side on a cold table it would be very easy to trace the course of each organ through the body. This principle of making serial sections has added wonderfully to our microscopic technique.

The object we are studying (the mosquito larva) is put into a moderate amount of turpentine and gently warmed. Small shavings of paraffin are slowly dissolved in the turpentine, until the proportion of paraffin is much larger than that of turpentine. Finally, the object is lifted over into warm melted paraffin, in a folded paper box and is then allowed to cool. The mosquito larva is now not only imbedded in paraffin but is absolutely penetrated with it.

After cooling to a solid mass the excess of paraffin is next cut away until there remains a rectangular block of paraffin but little larger each way than the larva itself.

We now turn to an instrument called a microtome. In the form we shall consider, this consists of a keen-edged knife, supported rigidly with its sharp side up. The paraffin is fastened to a holder. Rotation of a wheel throws this holder up and down, before the face of the knife, advancing it a little each time. This leaves on the

knife at each revolution a thin slice of paraffin, containing a "section" of the larva. If the block of paraffin has the right consistency, each new slice pushes the preceding slice down the surface of the knife, the edges of the two adhering to each other. Continued cuttings thus form a ribbon of paraffin with "serial sections" in it, the sections of course all retaining their proper order. The ribbon of paraffin is usually less than a thousandth of an inch in thickness, and perhaps a quarter of an inch wide. In this ribbon lie the sections of the larva, in a complete series.

These sections must now be mounted. The microscope slide is a piece of glass three inches long by one wide. The surface of the slide is brushed with a little white of egg. On this, pieces of the ribbon about two inches long are laid in order until much of the surface is covered, leaving just enough at one end bare to hold the label. The slide is now gently heated. The paraffin strips flatten against the glass, and may be pressed tight to it. The albumen of the egg coagulates and pastes the sections firmly to the glass. This whole is now immersed again in turpentine which dissolves away the paraffin, leaving the sections of the larva fastened in order on the glass slide.

To make the structure of these sections more evident they are now stained. Again a digression will make this process more intelligible to one who has not seen it done.

Supposing you were a manufacturer of textiles. An importer shows you a beautiful fabric you would much like to imitate. You can see it is made of silk and wool and cotton. What you want to know is how many threads of each run lengthwise and how many crosswise. You might

put the piecce of white goods into a red dye that is "fast" for silk, but washes out of wool and cotton. After leaving it here for a time the sample is washed thoroughly, leaving the silk threads stained red. Then follows a second immersion, this time into a blue dye, fast for wool, but not for silk or cotton. This again is followed by a thorough washing. Now the problem is much easier. All the silk threads are red, all the wool blue, all the cotton white. Counting under a magnifying glass is now easy.

A process exactly similar in principle is followed in staining objects for examination under the microscope. Some stains show up cell wall, some nucleus, some protoplasm. Some are especially good for fat, others for nervous tissue.

The glass slides containing the sections of larva are dipped by a quite intricate process not necessary to follow in detail, into various stains and washes until finally they are back in the clearing solution once more, and are transparent, and quite variedly colored.

Now a transparent cement, Canada Balsam, is poured over the sections, a glass cover, little more than a hundredth of an inch in thickness is laid on it and pressed down. Any Balsam oozing out from beneath the cover is cleaned away, and the slide set aside for the cement to harden. A label is added and the slide is now ready for study.

This method of preparation had not been long in use when Weismann did his work, and he learned to do it most effectively. He was not alone, or even the first in making many of his observations. But his work was so careful and his deductions so striking and so convincing that he vitalized our ideas of heredity, and gave a physi-

cal basis for understanding why Mendel's laws are true.

The first of Weismann's two great contributions to the theory of biology is the idea of the "Germ Plasm" with its associated deduction, that "acquired characters are not transmitted." The second is his explanation of the significance of the complicated process (karyokinesis) that goes on in the nucelus of the cell just before it divides into two, in the course of its multiplication.

First as to the germ plasm. The egg of any animal consists when it begins its development of a single cell, known as the fertilized egg cell. This divides into two, these into four, then eight and so on, the whole however remaining in one clump, the size of the original egg. When the cells grow abundant they begin to arrange into layers and then organs. When there are about sixteen cells (at least that is the number in some animals) one of these cells has a peculiar history. It remains like the original egg cell, but continues to multiply unchanged in general character through the entire life of the animal. The other fifteen cells grow more and more different. These fifteen multiply and diversify until they become the entire animal, with all its organs including the glands (ovaries in the female, testes in the male) in which the eggs or the sperm cells mature. But the mother does not produce the eggs in the ovary. They never were a part of her ovary. They descended directly from the original egg cell, but were never ovary. They simply lie in and are developed in the ovary. In other words *they never were a part of the mother.* They owe their qualities, not to the mother; they and the mother, insofar as they are alike, owe that likeness to the fact that they both developed out of the same egg cell.

This line of eggs, descended directly from the original eggs growing up within the mother is known as the germ plasm. It is a thread of life continuous through all the generations past. In distinction from it the mass of cells developing into the body of the mother are known as the soma. Thus in each generation an egg grows up into two things, one is the body (soma) of an animal, which lives its time and perishes. The other is the entire collection of eggs the animal will send out. Such of these as escape fertilization are gone—like the soma. Some however are fertilized and develop again into a soma and its contained germ plasm. Thus no egg or sperm cell has any cell in its ancestry, no matter how far back, that died. The line of germ plasm is immortal through an indefinite past.

I spoke of an associated conclusion or corollary, that Weismann had drawn from his idea of the germ plasm. It is this, since the offspring do not owe their characters to the mother, but to the egg from which she developed, then it is clear that nothing that can happen to change the characters of the mother, will alter the qualities of her offspring. In other words, *there is no inheritance of acquired characters.*

We will suppose a case, that might easily occur. Let us imagine a woman whose early life is spent in depressing poverty, on a small piece of land. Her day is so full of work there is little time for anything else, except such rest and sleep as she is able to snatch. Now let us imagine it is suddenly found that the land holds mineral wealth, ore, oil, or whatever it may be. It becomes instantly marketable at a large price. The land is sold and now life for this woman and her family takes on a new aspect.

Under the new conditions there is time and means for pleasure and improvement. The children, those born before the change and others that came during later life, share in the new wealth and opportunity.

We will suppose the mother, in her altered existence, finds she enjoys music, and later still, that she has real capacity for singing, a gift she had never suspected before. She cultivates that voice, and comes to be a really fine singer. Now for Weismann's conclusion, that acquired characters are not transmitted.

The children born before the mother discovered and cultivated her power are quite as likely to "inherit" her musical ability as those born later. Indeed if she had the power, and had never discovered and cultivated it, they would have been just as likely to have musical ability, though under the old circumstances they might never have known of their power. They can inherit their mothers power, but not her training.

When Charles Darwin first published his remarkable book on "The Origin of Species" there was no doubt in the mind of anyone, at least none commonly expressed, that parents could impress their newly gained powers on the children born to them after such acquisition.

Lamarck was the great Evolutionist before Darwin, though the scientific world had given him little attention. Such as there was, consisted chiefly of ridicule, led by Baron Cuvier, the great anatomist. Lamark believed and taught vigorously the result of continued exercise on both the organ and on its function. There was no doubt in his mind that such increase would favorably affect the later offspring.

Similarly any organ lying long unused gradually grew

weaker and then dwindled away and the diminished condition could appear in the offspring.

Darwin took this idea of the inherited effects of use and of disuse so entirely for granted that he made a theory to account for the method of its accomplishment. He called the process pangenesis and he assumed that each portion of the body threw into the blood stream small particles, called pangenes, which flowed throughout the body with the blood and eventually settled in the new eggs or sperm cells thus carrying the qualities, of the parents, both original or more lately acquired, into the new life. This theory had only mild acceptance up to the time of Weismann's discoveries, and eventually fell into entire disfavor, never to revive.

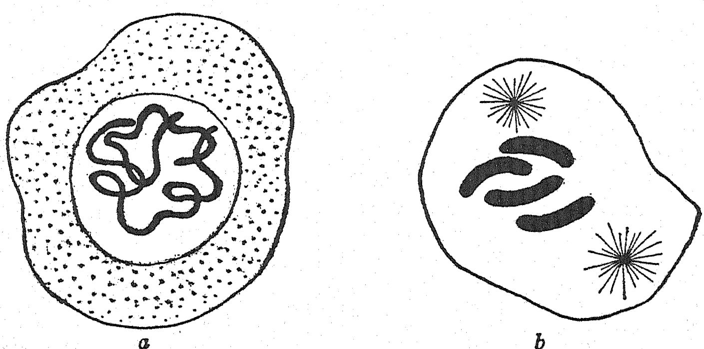
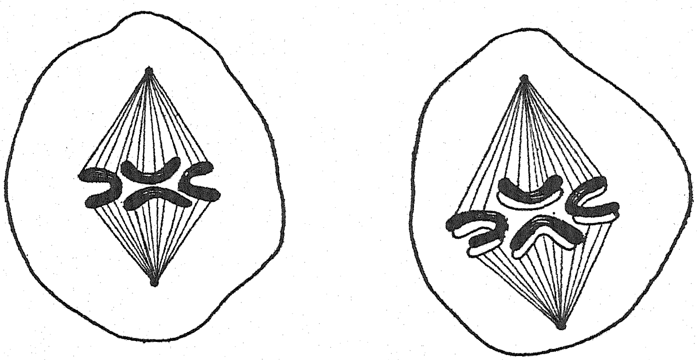


FIG. 2—Early stages of nuclear division. *a*—The thread forming; *b*—The threads broken into short lengths and the lines reaching for them from the centers.

The study of the cell, its contents and its behavior is known as cytology. Weismann was an early example of the students of this branch of biology and one of the best. While others had noticed and described the process he gave the first vital explanation of the procedure going

on in the nucleus of the cell in preparation for multiplication by cell division.

What happens is this. The contents of the nucleus of the cell slowly streaming about, grow at first somewhat curdy and gradually stringy. Finally a long slender continuous thread is formed (Fig. 2*a*) which later breaks into short lengths (Fig. 2*b*). The number of pieces is always the same in the same sort of cell. In the onion it is twelve. In a species of thread worm parasitic in the intestine of the horse, the number is four. The smallness of this last number has made this obscure animal famous amongst students because its cell division is so easily studied.

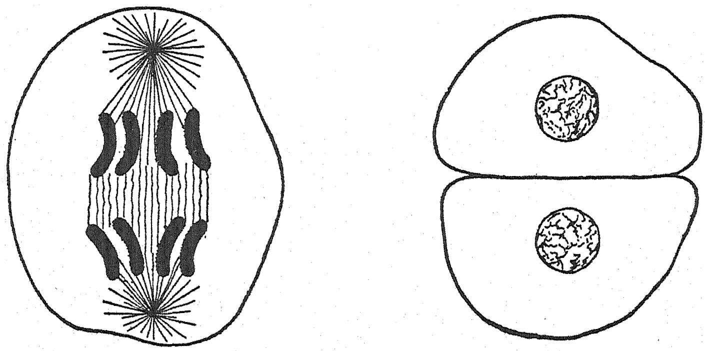


a *b*

FIG. 3—Middle stages of nuclear division. *a*—Drawing the sections into position; *b*—Splitting the sections.

While this thread has been forming and breaking, two small objects, mere dots (centrosomes) in the cell, are taking positions on opposite sides of the dividing thread. From these centers lines are reaching out to the fragments of broken thread (chromosomes) and drawing

them into a common level, half way between the centers (Fig. 3*a*). Fine lines seem to reach from the centers and grasp the fragments, each of which has now bent into a horseshoe, the toe lying towards the center of the group. Now comes the crucial part of the process, if Weismann interprets it correctly. Each horseshoe (chromosome) splits in two from end to end (Fig. 3*b*). The sundered halves sweep away from each other towards the opposite centers (Fig. 4).



a *b*

FIG. 4—Later stages of nuclear division. *a*—Halving each section; *b*—The division completed.

The wall on each side of the cell dips slowly in, a partition thus forming between the two halves of the cell. Each of these new, daughter, cells thus has in it one half of each horse shoe. These horseshoes grow stringy, then curdy and again disappear. When later they reappear, to divide the cell once more, they have regained their original size, evidently by growth. The new cells, if in an egg cell may for sometime fail to enlarge, the entire egg remaining of the same size while the number of cells into which it has divided has become many times greater. Even-

tually however each cell enlarges. In the growth of tissues and bodies after the embryonic development it is rather the enlargement of individual cells than their multiplication, to which growth is due. There are not many more cells, comparatively in a man than there are in the new born babies.

As before remarked, other men had discovered this process earlier than Weismann, but it was he who first clearly recognized and described its significance, and persuaded the biological world of its importance.

He says each chromosome is made up of a series of "determiners" arranged in single file. Each determiner decided the development or behavior of that cell in one respect. Later workers doubt the one determiner to each character as always true and think one determiner may influence several characters and perhaps sometimes one character may be decided by a number of determiners. All are agreed that in the chromosomes lies most if not all of the power to decide the possibilities of development. It is also clearly demonstrated that in certain animals, certain definite parts of each chromosome are connected with certain peculiarities of development. It is coming to be the fashion amongst later students of heredity to call these determiners genes.

This whole idea is too new to be entirely settled in all respects. But amid the diversities of opinion, all working biologists are agreed on the main facts. The physicial basis of heredity lies chiefly in the nucleus, almost certainly in chromosomes. *It is these we inherit,* that is, it is these which pass to us through our parents. Likeness between the child and his mother are due to the fact that in early cell division of the egg which grew up into

the mother, one cell, with similar chromosomes to those of the mother, became finally all the eggs the mother is to send out, and each of these eggs starts out with exactly the same chromosomes as those which influenced the development of the mother. As will be explained later just before these new eggs become ripe, each throws away not one half of each chromosome, but one half of the whole number of chromosomes. This is known as the reducing division. In the father the same process goes on, resulting in the production of sperm cells each containing one half the number of chromosomes found in the cells of the father.

In fertilization an egg from one individual and a sperm almost always from a different individual, fuse. Now the fertilized egg contains its full number of chromosomes, half of which are like those which led to the development of the mother, the other half like those which led to the development of the father.

So we see there is a "river of life" the waters of which subdivide again and again into streamlets. Each of these joins with a similar streamlet from some other "river of life." There is no break in the continuity. Each human being is the product of unending joinings of half streams in the past, so that he can look back to an ancestry ever growing more wide spread. But he is not the sum of all these ancestors.

He cannot inherit all from all of them. Each of his ancestors in ripening the sperm or egg cell that came in his time threw away, so far as that cell is concerned, one half of his chromosomes. Then he added this half portion to a half portion from the mother. This process went on in every generation. The farther back one goes the fewer

of his qualities is he likely to owe to that particular ancestor, and this Galton shows, is in a mathematically determined amount.

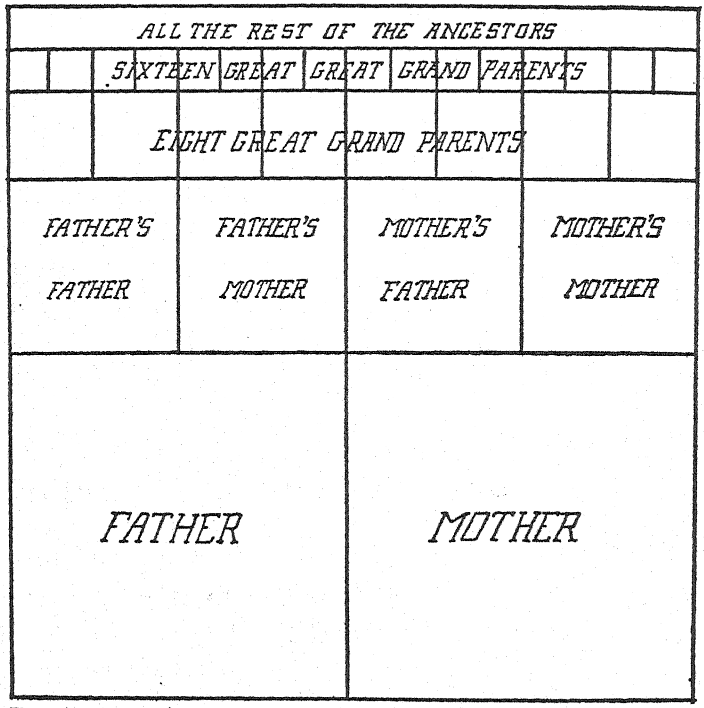


FIG. 5—Galton's figure showing the proportionate influence of each ancestor.

CHAPTER IV

GUINEA PIGS AND FRUIT FLIES

SINCE nineteen hundred quite a new era has arrived in the study of heredity. Biology has become an experimental science. In earlier years almost all the conclusions had been drawn from observations on animals and plants in a state of nature. Mendel had worked experimentally with peas but his work had been almost entirely disregarded. All the great students of evolution were field naturalists. Darwin himself had found his start in a five year voyage around the world. The co-discoverer of Natural Selection, Alfred Russell Wallace, had had an early trip to Brazil and just before his announcement, with Darwin, of the selection idea, had studied most thoroughly the distribution of animals over the islands of the Malay Archipelago. He had in truth made one of the finest studies in Geographical Natural History we have ever had.

Thomas Huxley too, had a four years voyage in the Rattle-snake. He had towed his net through the tropical seas and captured the multitudinous floating animals, mostly microscopic in size and radiantly beautiful. His studies of these creatures were most fruitful in biological advancement. We think less of them in remembering Huxley only because his later work in the anatomy of four-footed animals overshadowed in importance every-

thing else he did because it led him to the first intimate and capable comparisons between the skeletons of the monkeys, the apes, and men.

Earnest Haeckel, in Germany, had a similar history. While he made no such lengthened journeys as the others just mentioned, he went with greater frequency than they. Almost every year he made a trip to the Mediterranean, or to the North Sea and gathered floating material. Probably no other Zoologist has equalled Haeckel in his ability exquisitely to portray the beautiful forms his net brought up. A more lengthened visit to Teneriffe and finally one to Ceylon and Java rounded out his acquaintance with the field and helped him to his marvelously skillful practice of building "family trees" of the animal world. While Haeckel came too soon for his trees to be a permanent contribution, they stimulated other men in later years to more finally valuable efforts.

These are the great names in biology during the latter part of the last century and all of them gained the foundations of their knowledge by abundant collecting, painstaking dissecting and portrayal, and thoughtful deductions from their studies. They laid firm and deep the foundations of modern biology.

There remains another side of the work. If there has been evolution, it must be going on now. The process may be slow. This only makes it the more necessary that we devise meticulous means of measuring the progress which must be going on under our own eyes.

This means that we must control the conditions and record the results with unending patience and minuteness. At the bottom of all evolution must lie heredity. There can be no real understanding of the former that is not

based on a thorough acquaintance with the method of the latter. This means we must examine parents most carefully and then hunt for them in their children.

For this purpose man is too long lived an object of study. We must have some creature that multiplies rapidly under domestication, and whose mating we can control.

Practical medicine had come to use one animal for very many of its experiments. To study the effects of disease it was not uncommon to endeavor to infect the guinea pig and study the result. This gentle little creature was being bred in the laboratories of the medical schools. What more natural than that the biologist should turn to it? It had many qualities that made it a most convenient subject with which to experiment.

The guinea pig is native to South America. Evidently his name should be Guiana pig. The mistake is too old to correct now and he will doubtless always go by the old name. Bigger than a rat, and smaller than a rabbit, and much more tractable than either of them, he splendidly serves the purpose of the experimental biologist.

While in his native home he bears a grayish brown coat, he has been altered in captivity until we have pure white (albino), pure black, yellowish, and mottled forms. Originally the hair was rather short, now in some varieties it is very long. The coat in the original is quite smooth. In some varities it grows in "crowns" or "cow-licks" and is quite rough.

Best of all, it begins to breed when it is two months old; the domesticated form breeds often, and produce usually four or five young. Occasionally there may be as many as twelve in a single litter. If the attempt were purposely undertaken with a prolific pair, to see how

many could be crowded into a year, it has been estimated by good authority that the pair and all its progeny and descendants might count up to a thousand within the twelve months. This power of rapid multiplication naturally attracted the attention of the students of heredity and many men have worked with the guinea pig.

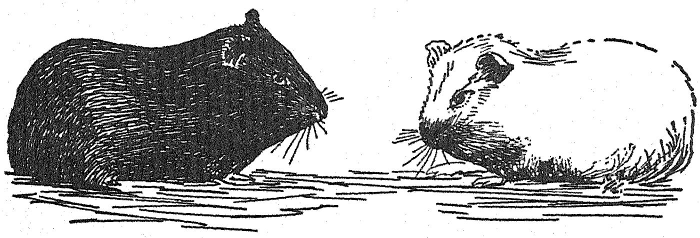


FIG. 6—Black and white guinea pig parents.

A number of people have studied their mating to see whether the Mendelian law held for animals as well as for peas. The confirmation at the hands of Castle of Harvard, as well as with many other workers, is complete.

If a pure black strain of guinea pig is mated with a

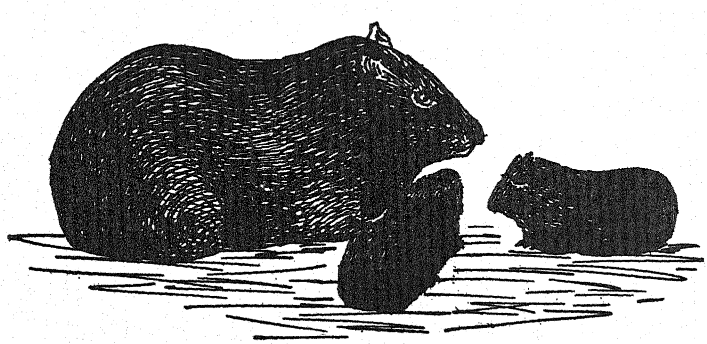


FIG. 7—Mother of Figure 6 and two young guinea pigs, showing black dominant.

pure white (Fig. 6) the first hybrid generation is always and entirely black. It matters not the least which of the two sexes is white and which black (Fig. 7). If two of this hybrid generation are mated they yield, in their progeny, on the average, three blacks to a white. Of the three blacks one is pure black and the other two are black concealing white (Fig. 8). Here blackness in the

FIG. 8—Three black guinea pigs and one white, all offspring of the two black young of Figure 7.

guinea pig is dominant and white recessive, just exactly as Mendel found yellowness to be dominant over greenness in peas.

In similar fashion short coat in the guinea pig is dominant and long coat recessive. Rough hair is also dominant over smooth (Fig. 9).

This makes it possible to have one of those particularly interesting cases of inheritance where the parents differ in three pairs of characters. A colored, long haired, rough coated pig was mated by Castle to a white, short coated, smooth pig. The result was that there were produced, in repeated matings, a large number of pigs embracing all of the eight possible combinations of these three differences. It was quite evident that each pair of

qualities went in and out of combination exactly as if that had been the only pair in which they differed. Mendelism is just as true in animals as it is in plants.

The Harvard laboratory carried out a still more remarkable experiment, this time confirming Weismann's teachings about the germ plasm.

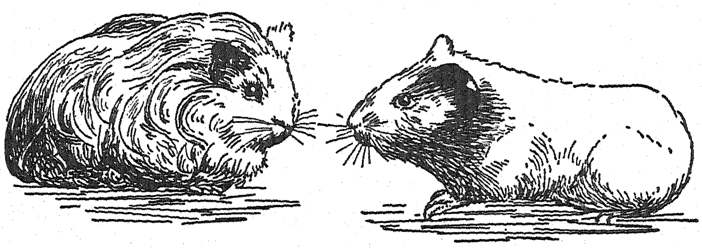


Fig. 9—Rough and smooth coat in guinea pigs, rough being dominant.

For some time past, in the great research laboratories, with minor animals and to a much less degree in the operating rooms of great hospitals with human beings, grafting of living parts into another living body has been carried on. Long ago it was not uncommon to plant broken fragments of the femur of a rabbit against the cleaned periosteum of a bone, a portion of which had died and had been removed. Over these fragments new bone had spread and the whole healed and filled the place from which the dead portion of the bone had been cut.

Later it became possible to replace lost portions of tendon and even of nerve. Still later it was found practicable to remove a diseased kidney and replace it by a healthy specimen taken from a man who was willing to spare one of his.

Finally it was decided to experiment with transplanting ovaries from one guinea pig into another. After a

time they learned how to do this and have the migrating ovary reform its attachments and go on naturally with its old work in the new place. When this technique had been perfected a revolutionary and revealing experiment was made. It will be remembered that black in guinea pig coat is dominant over white. Hence a white pig is

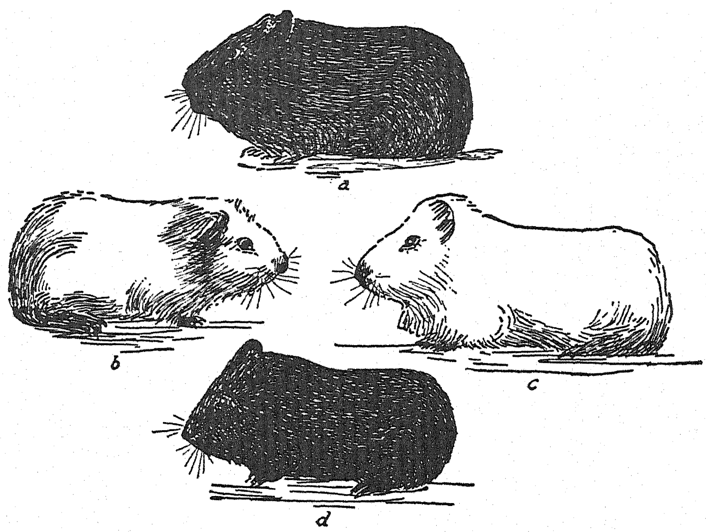


FIG. 10—Guinea pigs, showing the result of transplanted ovaries. *a*—The source of the ovaries; *b*—Female receiving the transplanted ovaries; *c*—Male mated with *b*; *d*—The result of the mating.

sure to be pure white; it can conceal no blackness. A black guinea pig may be pure or not, only a breeding experiment will decide.

Castle after etherizing a white guinea pig removed its ovaries. Into their place he placed an ovary removed from a young guinea pig whose pedigree assured him it was a pure black. After the wound had entirely healed,

and the pig was going about its daily routine in entire naturalness, he mated it with a white male, sure, of course, to be pure white. The mating was successful and a single pig was the result. It was black. The apparent mother was white and the father was white, whence came the blackness? The answer is plain. The white

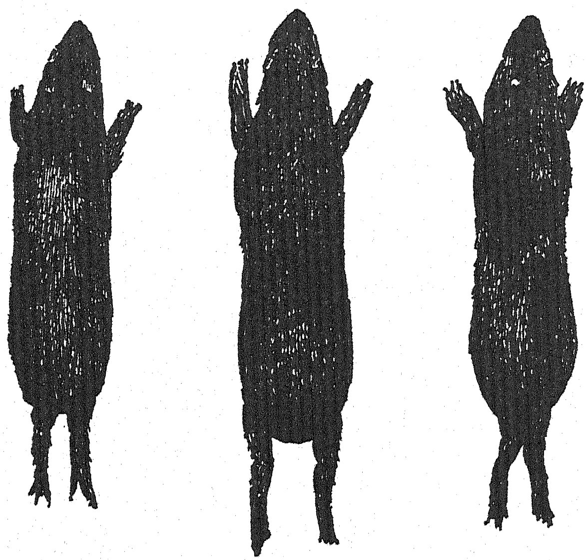


FIG. 11—Later offspring of the pair in Figure 10.

female was only apparently the mother. The black guinea pig, out of whom the ovaries were taken and placed in the white pig, was really the mother of the progeny. The egg came through her, even though the white mother fattened it and sent it out. The cells of the germ plasm came from an egg whose somatic plasm had developed into the black mother.

After a time the same two whites were mated again. This time two pigs formed the litter. Both of them were black. A while later a third mating of the same white pair occurred. This time the mother died before the pigs were quite ready to be born. A postmortem examination however showed three pigs advanced enough to have their hair. All of them were quite black.

There could scarcely be a more conclusive experiment to show that the germ plasm is a separate strain from the soma; that the mother does not produce eggs, they simply pass down through her. When they are ready, she fattens them and sends them out to meet or miss their chance.

Furthermore, we have here the clearest sort of evidence that acquired characters are not transmitted. These eggs with their black characteristics had grown up with an entirely new and white body about them. It might easily be imagined under such circumstances if even the first egg should develop a black pig, later ones would be affected by their longer sojourn in the white body. Such however was not the case. For three separate litters the blackness held undiminished. The white pig was only the foster mother of the blacks, not their real mother. The mother does not produce the eggs; they descend directly from the same egg which developed into her. The germ plasm is independent, for its hereditary characters, of the body of the mother—the soma. Acquired characters are not transmitted.

For a long time those who believed that there was such passing on of developments in the parent had pointed to some experiments by Brown-Sequard on guinea pigs. He was a nerve specialist and had performed operations

on the spinal chord of the pigs. They had lost sensation in their hind legs as a result. By a behavior not uncommon amongst such animals one of them had gnawed her own hind toes until they were distinctly deformed. Some young produced by this mother, after her deformity, had toes that had a certain amount of malformation. This was urged by Brown-Sequard as an instance of the passing of the mutilation from one generation to another.

There must have been some other explanation. For hundreds of years men have chopped off the tails of lambs. They are still born with long tails. Even more conclusive is the fact that Jewish male children have not lost the foreskin though their ancestors have been circumcised through more than two thousand years.

The guinea pig has helped us to still another biological discovery. Steinach, in his preliminary studies on the transplanting of sex glands found one of his first satisfactory reults in case of the guinea pig. He removed the male glands (testes) from a young guinea pig and planted between the skin and the muscles on the under side of the body, the living ovaries of a young female. These matured and while, of course the eggs found no exit, the interstitial cells (of which more will be found in chapters 18 and 20) poured their secretions into the blood of the young male and stimulated him to develop the milk glands until they grew as prominent as in a female.

Following this lead, Starling suggested that just as the development of the ovaries produced enlargement of the milk glands so the nearly developed embryo within the mother must secrete a substance which stimulated the glands of the mother to their flow of milk. Accord-

ingly, a nearly developed embryo rabbit was taken from its mother and a serum made from it. This, injected into the veins of an unmated female rabbit caused milk to flow.

It is not impossible, in the future development of dairy practice, that when a slaughtered cow is found to be carrying a calf nearly at its time of birth, this embryo will be taken from the mother and a serum made from it, which, injected into cows which are not producing calves of their own, will stimulate them to milk giving. In this way dairy cows can probably be "freshened" without the drain and the loss of time involved in producing calves of their own.

So the guinea pig has been one of the chief means of assuring us that what Mendel had proved true in the plant world holds equally in the animal world; and that strains of germ plasm run uncontaminated through bodies of generations of higher animals as Weismann found them to run through insects. Lately guinea pigs have evidenced such results of transplanting glands as may in time revolutionize our dairy practice.

There was a marked gain in time, in number of examples and in possibilities of determined mating that came when guinea pigs, instead of human beings, were studied in working out the problems of heredity. Results began to make themselves apparent in very short time. There was however a new animal to replace the guinea pig and give returns in every way as satisfactory, of greater variety, and a hundred fold more rapid. The guinea pig matured in two months and was then ready to mate. Drosophila, a common fruit fly, ran through its entire life, under favorable conditions, in less than two weeks

and its young had lived only the same length of time before they too were ready to mate. One generation of guinea pigs passed at best in two months; Drosophila had two generations in one month. The guinea pig had usually four or five and at best a dozen offspring. Drosophila might have three hundred as a result of a single mating. There are a few definite points in which the guinea pigs varied. Experimenters counted it fortunate that they could find three pairs of contrasted characters in one pair of pigs. There would be no difficulty in finding a dozen pairs of characters in one pair of Drosophilas.

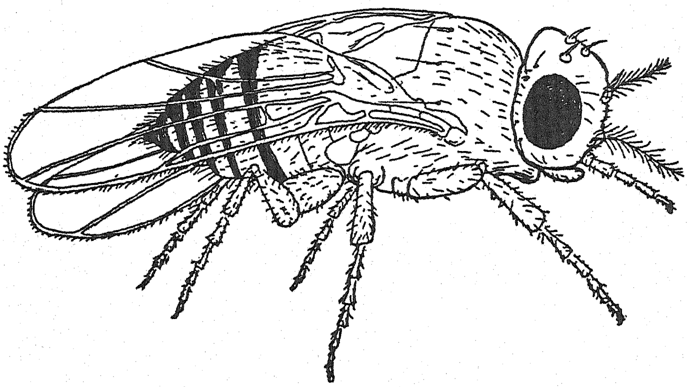


FIG. 12—The fruit fly (Drosophila) used in experiments in heredity.

Every one is acquainted with Drosophila or its near kin. Though it has never been formally introduced and the name was never passed, no one has failed to see it. You buy a basket of grapes, lift the lid and use some of the fruit. The lid is pressed down again and the purchase set away, and forgotten for a while. On going back and reopening the basket a cloud of small, dark flies pours out. These are fruit flies. Anyone who has seen

an old pile of apple pomace, refuse from which the juice has been pressed in making cider, has had the opportunity of seeing more fruit flies than there are people who have ever lived on the earth.

It is very easy to breed and rear fruit flies. They are much less trouble to keep than guinea pigs, and the laboratory smells much better. A dot of overripe banana, on the side of a test tube, a pair of properly chosen and pedigreed fruit flies, a wad of cotton to close the mouth of the tube, and the experiment is set to give in a few weeks a couple of hundred answers to the question as to what may result from the combination of such characters as the parents possess.

The leader in this work has been Dr. Morgan of Columbia, aided by his associates. They have given a greater definiteness and a more detailed character to some of the answers than we have heretofore ever won.

Doubtless the most valuable addition to the theory of heredity made by the students of the fruit fly has been our knowledge of the accurate geography of the chromosomes. This result was gained after long and patient study, by Morgan and his associates, on the vinegar fly (*Drosophila melanogaster*). This fruit fly gained its name because its early stages can and often do live in vinegar.

When Mendel studied his peas which differed in but few characters at most, he believed each peculiarity went through its history of generation after generation absolutely by itself, appearing just as often as the theory predicted it should.

Morgan found that certain characters seemed to stick together, and hence appear in the company of each other

more frequently than the theory demanded, and to appear separately less often than they should. Slowly he decided that in the vinegar fly the characters were usually found in four groups and that these seemed ordinarily to go in and out of combination together. Interestingly it proved true on microscopic examination that there was a physical basis for this grouping. Each body cell had four pairs of chromosomes in its nucleus. Fortunately for purposes of study, each of these chromosomes differed enough, in appearance from its fellows, to permit identification. So gradually it became sure that these qualities were distributed amongst these chromosomes. What went in and out of combination were not separate genes (determiners of Weismann) but whole chromosomes. This is Morgan's theory of linkage.

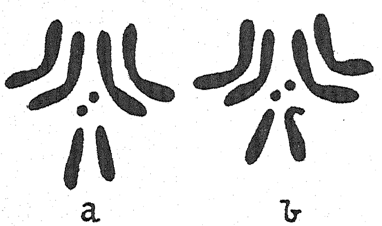


FIG. 13—Chromosomes of the fruit fly. *a*—Female; *b*—Male, (after Morgan.).

It will be shown later that one of each of these four pairs had come through the father with the sperm cell and one had come through the mother in the egg cell.

It was stated a few paragraphs ago that the characters "usually" went in and out of combination in groups. There was much difficulty experienced for a time from the fact that they did not always behave in this way. Soon it was found that when a few characters acted differently it was always the same characters of any group that showed the odd behavior. Later it became evident that what had happened was that two chromosomes had

become twisted, and when they broke apart, each had become divided, and that they had exchanged divided ends. Hence after the separation the genes were regrouped thus changing the constitution of each chromosome. It was always the corresponding members of pairs of genes that had thus exchanged. This process was called crossing over.

These crossings might occur anywhere in the length of the chromosomes. This fact yielded the possibility of slowly locating in the chromosomes the gene responsible for a particular character. When once the position of such gene had been discovered, it proved always to be in that particular position and in that particular chromosome.

In this way Morgan has determined the geography of the chromosomes of Drosophila. He has placed about thirty genes each on the three long chromosomes and about three on the one short chromosome.

What does all this mean? Clearly that what we inherit is chromosomes built up out of genes. We do not inherit blue eyes; we inherit one particular gene, located on one particular chromosome. This gene has probably a certain chemical constitution. Brought into action in part of an eye it compels that eye as it grows to be free from coloring matter on the front of the iris, though like all other human eyes (except albino) there is still abundant color on the back of the iris. It also decides that the iris shall not be thick enough to look gray, but shall partly disclose the color on the back and partly the blood in the iris, in such fashion as to give the eye a blue appearance, much as the veins look blue through the skin.

Hence we are what we are structurally, fundamentally because we have received through the mother in the egg cell one set of genes assorted into chromosomes, and through the father a parallel set of genes, also assorted into parallel chromosomes. *These determine all the possibilities.* Not all of these possibilities may be accomplished. Circumstances may not favor their development. In each pair of possibilities, one (the dominant) will almost inevitably overshadow the other (the recessive). So at best only one of each pair of genes may work out its destiny. In many pairs no result may come because of a repressing or restraining environment.

Children of the same parents may differ because they are different shuffles of the pairs when the egg cell and the sperm cell matured (more of this later). Roughly speaking, the differences ordinarily found in members of the same species are due to such sorting out of the genes.

But it is clear that, though most new characters are due to reassorted genes, while the genes themselves are most stable, there must come at least an occasional change due to a real change in the gene itself. The great steps in evolution must be due to altered genes. There is not the faintest proof of how this change comes about. It does not seem possible that alteration in the body of the mother (or father) induces the change in the gene. The genes that carry whiteness in guinea pigs may go, in both parents through many generations of black hybrid pigs, yet when the two white-determining genes meet they produce just as white a guinea pig as their distant white ancestor. They have not been blackened by passing through the bodies of generations of black guinea pigs.

As in Darwin's time, we see how natural selection will preserve a favorable variation once produced. We are still as uncertain as he was as to how the favorable variation is caused. We are doubtless nearer the solution. We are now quite certain the change must appear first in the gene. Later experimental work will in all probability determine how the gene is affected. At present it looks as if the student of heredity (the geneticist) must hand over this part of his problem to the physiological chemist. Perhaps the present study of hormones, secreted by our ductless glands and influencing the growth and development of all parts of the body, will lead to the solution of our problem. When we understand how adrenalin tells the liver to throw sugar into the circulation, we may know better how a gene influences development. When we really know this, we can experiment on trying to change the constitution of a gene and thus alter the development—that is change the path of evolution.

And then again, we may find all this, and have it lead only into a deeper and more fundamental aspect of the problem than any of which we are thus far conscious. This is the glory of all science—and at present the especial glory of the study of the chromosome by the biologist and of the atom by the physical chemist. The pebbles we have picked up on the beach are small compared with the great ocean of the unknown. But these pebbles owe their shape to the reaction of the ocean on their interior constitution. When we know the pebble well we have a step towards the knowledge of the ocean.

CHAPTER V

THE MEANING OF TWINS

IT OFTEN happens that things we have known for a long time and to which we had given only passing attention, get a new explanation, and at once take on a significance they never had before. To my mind there is no other set of circumstances that so thoroughly throws light on the relation between heredity and environment, as the contrast we find between two different pairs of twins.

I choose two sets out of my own experience, all of them pupils in my own class room. The first pair is made up of a brother and sister. When they were members of my class they were about seventeen years of age.

The boy was tall and slender. He had what the anthropologist calls a long head. His skin was moderately swarthy, and his hair straight and black. His eyes were sparkling and very dark. He was most eager in his relation to the work of the class. He earnestly took part in the recitation, seeming hungry for everything that came up. He seemed quite unwilling to miss anything that went on.

A little farther back sat his sister. She was shorter by several inches than he. There was much more than the average difference between boys and girls of that age. She was comfortably stout while he was markedly thin. Her head was round, his long. Her hair was curly, while

his was straight; hers brown while his was black. Her eyes had a bluish gray iris and a gentle outlook in striking contrast to his, often flashing, black.

The contrast in demeanor was quite as striking as in physical characteristics. While he was eager she was contained and serene, though never listless. In every way, except in entire dependability, they were in striking contrast.

Yet these two were born of the same parents, in the same hour. They grew up on the same farm, in the same home, eating from the same table. They played together constantly. As time went on, they attended the same elementary school and went together to the high school. Later they both came to the same professional school to prepare for teaching. It is not particularly common for brother and sister even though born at different times, to differ as much as these two did.

On the other hand, in another class, were two sisters. I never knew them apart. My only reason for calling them by different names was because they sat in different seats. Occasionally when I stood them side by side and studied them I detected little differences, but they were not marked enough to enable me to distinguish which sister was with me when but one came at a time. If I had asked one of them to come to my laboratory for any special work and the other had substituted for her, I would not have known the difference. Of course they added to the confusion by always dressing alike and doing their hair in the same way.

They both wore glasses of the same general appearance. While I have neither the skill nor the apparatus for measuring lenses accurately, I examined these by the rough

method of throwing the image of an electric light bulb on a screen, through the lens, and measuring the distance between the screen and the glass. The two lenses of the same pair differed from each other in focal length. The right lenses in both cases seemed to coincide in focal distance and the left lenses nearly coincided.

One time while talking to the class about finger prints, I took a hasty impression on a blank lantern slide. I made the imprints on the glass, in a row, of the left first finger of an entire row of pupils. When we projected the full set at one time on the screen I began to call attention to peculiarities of each print. When I came to the fourth, I said to the third girl, "You printed twice." "No, I did not," she replied. I said, "You can't get two prints so much alike." Number four said, "That is mine." Then I realized I had the prints of a pair of identical twins. I cannot say that, to an expert, these would have been indistinguishable. I only know they were very strikingly like each other, and entirely different from any other prints in the row.

A more surprising case, in some respects at least, has come into my experience, though I have not had this pair of twins in my own classes.

A pair of growing boys were known over the entire town not only for their great resemblance to each other, but for their well-known habit of mystifying their friends. Neither would usually identify himself, and both delighted in making their friends decide and not telling them whether they were right.

The story was common that, in sport, one would make an engagement with a friend and the other keep it, without recognition on the friend's part of the substitution.

The most remarkable instance of confusion however, I have from the mother of the twins. These boys had been together all through childhood. Apparently they were inseparable. Then they surprised their friends by going to different preparatory schools.

Commencement time came for one of the boys earlier than for the other. The first invited his mother to attend the ceremony. She went by train to the somewhat distant town. On getting off the car she greeted her son, and walked with him, chatting all the way until they reached the institution. Here to her consternation she came face to face with the boy who belonged there. Not until then did she realize that she had been walking and talking with the other boy, whom she had not expected to find there. She had called him by his brother's name. He as usual was enjoying her mistake and playing up to it. She was more than discomfited, she was annoyed to find that after eighteen years of acquaintance she could even passingly fail to identify her own children.

It is entirely evident that these three cases are not alike. The first pair were no more intimately related to each other than if they had been born of the same parents at separate times. Such twins as this are known as fraternal. They are very common. As a matter of fact they occur about three times as commonly as the other type.

The members of each of our second and third pairs are so strikingly alike, that there must be some essential difference in their origin and in that of the first pair. What can this difference be?

Fifty years ago a German biologist by the name of Roux had artificially modified the development of the eggs of a frog. The first step in this development consists of

the splitting of the one-celled egg into a two-celled stage. At this point Roux inserted into one of the pair of cells the hot point of a needle. This prevented its development. The other cell however continued to divide and redivide and form up. But in doing so, it formed one half only (right or left as the case might be) of the tad-

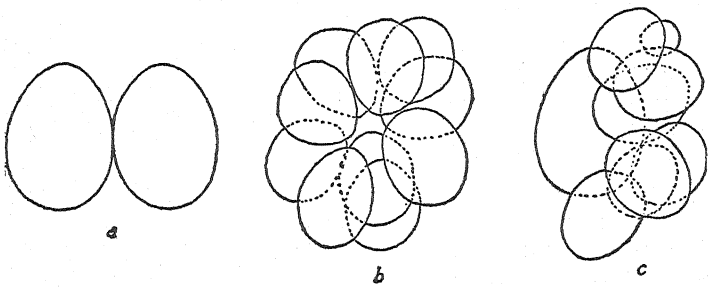


FIG. 14—Development of injured frog's egg. *a*—Two-celled stage; *b*—Naturally developed; *c*—Developed after killing one cell in the two-celled stage.

pole. This unexpected result led to a considerable set of experiments, by many workers, in modifying the development of eggs. A worker by the name of Schultze had turned frog eggs upside down and fastened them in that position. In one such case he found the egg developed into two embryos. Another observer, shaking frogs eggs when in their two-celled stage had been able to separate the cells without killing them. To his surprise each developed at least partway into a tadpole.

In a case which happened while I was pursuing my own studies, an incubator, in which were hen's eggs, was allowed to get too warm at the beginning of incubation. Several of the eggs on continued development produced twin embryos, which in this case touched each other at what would eventually become the back of their heads.

Shaking fish eggs has produced all sorts of stages of twins. Some of these were entirely separate. Many of them were partly joined. Sometimes it was the head only that doubled. Sometimes the twinning ran half way down the body. At other times two tails appeared on a single body.

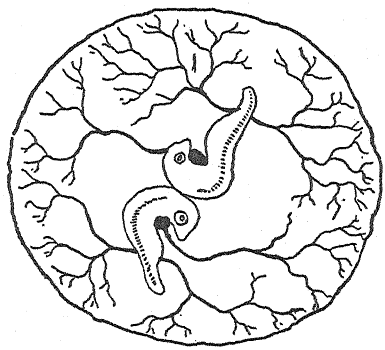


FIG. 15—Twin chicks in a hen's egg.

Professor Newman of Chicago University has recently reviewed the entire subject in the light of his study of the nine-banded armadillo. This interesting creature has been very fully studied. It proves to develop, as the usual habit, four embryos, each one running down one quarter of the single egg. Here it is quite clear we have as the habitual occurrence, four young at a birth. They are always of the same sex and always "strikingly" alike. Newman and Patterson studied the embryology of this creature very fully. They found that the armadillo produced not exactly quadruples but twinned pairs of twins. An egg that in early stages would normally, so far as all appearances go, produce a single embryo, halts for a time. This disturbs the process and when development is resumed it starts at two points on the same egg, as if it would produce a pair of identicals. Soon however each of these again halts and on resuming divides again, thus forming two identical pairs of identical twins. Both

twins of one pair resemble each other even more closely than one member of one pair resembles either member of the other pair.

The world knows the Siamese twins through the enterprise of Mr. Barnum. A number of similar cases have later been exhibited. I myself saw a pair of colored girls whose bodies were intimately joined to each other along the sides, towards the back, for the better part of the trunk. There were four arms and four legs. They seemed about eighteen years of age. The pair was by no means either ungainly or ungraceful. They danced beautifully together and sang duets quite pleasantly. More recently the Journal of Heredity has figured a mother nursing twins, one at each breast. The peculiarity lies in the fact that they are only twins back about to the waist. The rest of the body is one.

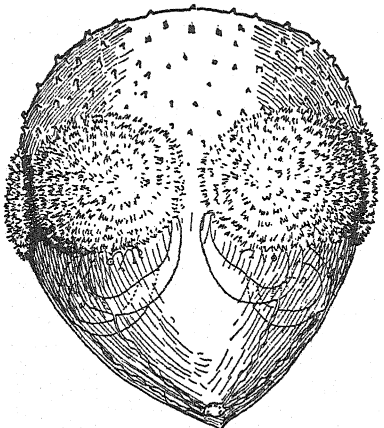


FIG. 16—Two pairs of twins forming in one egg of the armadillo (after Newman).

One more type of observation is worth recording. When twins of the first kind are born each is found in a separate "bag of waters" (amniotic sac) and each is attached to a separate "after birth" (placenta). In the case of the identical twins both are found in the same amnion and both are attached to the same placenta.

We have here then at least a little that goes toward the explanation of the possible contrasts between fraternal twins and the constant striking similarity between identicals. The former are from separate eggs, and have of course also been fertilized by separate sperm cells. In the first case each twin resulted from a separate shuffle and separation of the chromosomes in the mother and an equally separate shuffle and separation of the chromosomes of the father.

In the second case, each member of the pair inherits its qualities not only from the same mother and same father, but from the same egg and the same sperm cell, and hence from the same selection of the chromosomes of both the mother and of the father.

There is, it seems to me, no possible doubt of the bearing of all this upon the question of the relative influence of heredity and of environment on the qualities of the individual. In all cases of the first kind, that is of fraternal twins, not all the similarity of environment, both physical and spiritual, prevented them from being strikingly unlike, even to that greatest of contrasts the difference of sex.

On the other hand identicals are always of the same sex. Furthermore, even when, as is not infrequently the case, they are separated in early life and grow up in entirely different surroundings there is still the same startling similarity. The chromosomes are marvelously powerful to decide the sort of creature that shall come from the egg. Now and then circumstances may favor one and retard the other. I know of one pair of identicals in which one member was slightly taller, slightly stouter, slightly more vivacious than the other. Yet they were

still strikingly alike. No one would hesitate for a moment in placing them as identicals. I suspect some gland, perhaps the pituitary of one of them, had a better development, and stimulated more strongly the growth of its owner. But the alteration was a very minor one; the identity essentially remained.

I repeat what I said in an earlier chapter and am likely to say again in later portions of the book. The part played by heredity is entirely different from the part played by environment, in determining the character of the developing individual. Heredity decides all the possibilities. Environment may foster the development of certain characteristics and retard or even prohibit the development of others, but it produces nothing.

CHAPTER VI

HEREDITY ON THE FARM

THE farm with its choice crops and fine animals is one of the best places to see how man has won splendid victories in bending these plants and animals to his own service. He has confidently looked to heredity to furnish the basis and environment to stimulate its development. As early as we know Neolithic man and this means probably for ten thousand years, he has been taking under his care some of the wild plants and wild animals he found about him. What were the fundamental qualities he depended on in each case, and what has he made out of them?

Not many years ago a scout was sent out by the Department of Agriculture of the United States Government to look over the orient for any plants, wild or cultivated, that seemed to promise good results if grown in America. On the slopes of the Lebanon Mountains in Syria he found a short stiff grass with big seeds in a rather straggling spike. Close examination showed its probable identity. It was not a degenerate plant. It was sturdy enough in every way. Here at last seems to be what men have long hunted, the wild ancestor of our cultivated wheat. Here is undoubtedly a wild wheat. Is it ancestral or is it a return, after escape from cultivation? Its sturdiness seemed to point to the former; it is prob-

ably an unaltered, uncultivated descendant of the old wheat, and it still lives on in its old way, beside its sophisticated cousin, which, under the fostering care of man, has developed so far past it, at least in those qualities in which it is serviceable to him.

The grasses are all closely related to each other, from the smallest tuft that clings to the rocky summits of high mountains to the tall corn and cane and bamboo. In each case they form a fruit which contains but a single seed. The germ of this seed lies with its side against the more bulky food mass which is to nourish the germ while it is sprouting. If this is good food for a plant baby it is good for us. This food mass is of course larger in some grasses than in others.

Naturally when men gathered grass seeds they selected from the kind of grasses with the biggest seeds. To-day the Zuni goes out into the patches of wild grass with one of his beautifully woven basket bowls. Holding the bowl under the heads of the ripened grass he beats these spikes with a stick in such a way as makes the seed fall into his bowl. When he has gathered enough he takes the seeds to his home. He has there another woven basketry bowl without a bottom. He stands this on a smooth rock, pours in the seeds, crushes them with another stone or with a hard ended stick. The surrounding bowl, bottomless because otherwise it would soon be ruined, keeps the flying pieces of grain from being lost.

Doubtless here we have a very early method of making flour. The bottomless bowl is perhaps advanced. More primitive tribes use a deep mortar with a long pestle, or still earlier rub the grain on one stone with another stone,

much as we roll out dough. But details aside, we have here a very primitive process.

There is no clear evidence that Old Stone Age men, either Neanderthal or Cro-Magnon, owned cultivated plants or domestic animals. There is abundant evidence that Neolithic man, and very particularly the Lake Dwellers, had both.

Undoubtedly when man (or more likely the much more domestic woman) learned that he could plant seeds and they would grow up for him, he had reached a very important turn in his development. This could not come before he was advanced enough to stay at least a year in one place. Perhaps too it did not come before wild food became scarce.

Through many generations always the finest grasses were planted. Probably also, unfortunately, for many generations the best product was eaten. Man seemed slow in reaching the point, involving both forethought and self denial, when he kept his very finest seeds for planting.

The improvement of wheat up to quite modern time has been very slow. Recently it has gone rapidly. Heredity has kept it all wheat. Environment has decided what native qualities should be fostered. Some wheat had spread north. Some of this had seed which was hardy in constitution and stood cold well while dormant. In that climate it lay on the ground all winter and sprouted in the spring. From selection and careful breeding of wheat of this kind have come the somewhat small, hard grained wheats that have made the wide fertile flats of Minnesota and the Dakotas the great wheat fields of America and have made Minneapolis the milling center of this country, if not of the world.

Another wheat, larger and softer in the grain, sprang up in the fall. A mild amount of cold did not hurt the young stalks especially if protected by snow. These proved the suitable material for cultivating in our eastern states. This wheat is planted in the fall, and its fields are green all through the winter, though they are often covered with snow.

The biggest externally visible change in modern years is that some wheats were found which had lost the long bristles which naturally protect the grain. Fortunately, this beardless condition is a dominant character. Hence it has been easy to cross it with other varieties and to produce "beardless" wheat which is now usually planted. As late as my own boyhood most of the wheat in our neighborhood was bearded. Anyone who has "bound" sheaves after the old reaper, and who wore the woolen shirt then common has had a red band about his waist where the bristles got under his belt and around each wrist, where his shirt cuffs caught the prickly "beards."

So man found seeds good and soon ate many of them. Naturally he took the larger ones as they furnished the most meal. Already in prehistoric times he had found and cultivated wheat, rye, and barley. Oats followed and long after, Indian corn. These are all seeds of the grasses. Technically to the scientist the hull makes them fruits, but they have scanty fruit parts about a single seed which is much the largest part of their bulk.

There are other big seeds which man has found useful. One sort of them has a large proportion of oil which is a richly condensed food. We call such seeds nuts. Chestnuts, walnuts, hickory nuts, hazel are common in America. The most valuable, as the largest, of all is the co-

coanut. Some of these plants have been improved by cultivation. All of them have been less altered than our grasses.

A third group of seeds has also proved desirable because they contain much proteid. These have responded finely to cultivation. This set comprises those which grow in pods—peas and beans in their various forms.

In the case of all of these seed foods, nature gave the start. She put into them a store of nourishment intended to support the germ until it was established, and big enough to work for itself. Man found this habit, and by fostering care and ample feeding, he led the plant to store in the seed much more food than had previously sufficed for the plant baby itself. This makes the seed just so much more valuable to us.

Many plants in a state of nature are adapted to a region where the growing season is short, most of the year being either too cold or dry for active plant life. These are often in the habit of depositing during one season, in some underground portion a store of nourishment. At the oncoming of the following season such stores permit the plant to grow rapidly, produce its flowers and seeds and perhaps then die.

Man has taken this fundamental habit, hereditary in the plant, and fostered it by selection and favorable environment until we owe to it our beets, turnips, onions, potatoes, and such like plants, the fleshy parts of which are commonly known as "vegetables."

Nature has an interesting trick to deter animals from eating these fattened underground portions. She puts into them flavors that are unpleasant, even nauseous or biting, and sometimes quite poisonous. Man has overcome all of these. In potatoes he has cultivated out al-

most all the flavor. In onions, carrots, parsnips, he has mitigated it enough to make them liked by at least some people, though each is much disliked by many others. Manioc is a tropical root practically poisonous. It must be grated, the flavoring matter washed away, the water pressed out and the final pulp dried to fit it for commerce. Then it is tapioca. This is very nourishing, but so entirely tasteless after this treatment that it is always given a dose of some other flavor, in cooking, in order to make it palatable.

Here man again has intensified the hereditary storing habit of the plant, diminished its protective defense of flavor, and suited the plant to his own purposes rather than allowed it to grow to suit itself.

Certain of the plants, in a state of nature have a swollen, fine flavored, pulp about their seeds. This helps to secure the distribution of the seed.

If the pulpy portion and the seed itself are small, birds eat the berry and drop the undigested seed later, in a new situation where it has a better chance to grow than if it fell on ground of which its parent already has possession.

If the pulp is larger in bulk we are apt to call it a "fruit." Scientifically any portion that ripens with the seed is a fruit, whether it be the pod of a bean, the case of a beggar tick, or the meat of an apple.

How much man, by selection and fostering environment can do for such fruits is evident when we compare a big Ben Davis with the wild crab of our mountains. Yet in every point of its structure the finest modern apple shows the hereditary traits of the mountain scrub. We have put into it nothing entirely new. We have intensified some characters; we have softened down others;

sometimes even we may eliminate a character. But everything in the new apple was present in the old. Heredity determines its possibilities; environment, meaning in part, of course, man, decides which of these possibilities shall develop and which be restrained.

These pulpy fruits and berries have always been luxuries more than staple foods. They furnish little actual nourishment. But they taste very good, and man has kept them up and developed them. It is only quite recently we have come to understand how wise it was to cultivate them. We now know that they contain very valuable vitamins, which though present in most minute doses, are still highly necessary to healthy and vigorous life.

When we want examples of hereditary action that thoroughly interest us, however, we must look to the animals of the farm rather than to the plants. We feel ourselves to be so unlike plants that we can easily imagine that laws of heredity perfectly effective in the plant world might not hold in our case. But our farm animals are produced so entirely in the way we are, that we are more likely to realize that what is true of hereditary process in their case is much more likely to hold in ours than plant laws would. Let us turn to the animal side and see what the farm has to teach us.

First of all we must not forget that all our domestic animals were once wild. Of course man was about as wild as any of them. He lived a long time before he had reasonably tamed himself. A glance at the morning paper should convince him that the process is not entirely complete, even now.

Before he had become civilized enough to have a home

and live in it, at least long enough to plant and gather one year's crops, he had learned to domesticate a few of the animals that he had previously hunted. As game grew scarce he learned to pen it up and, later, to let it breed. Thus he had food at hand when he wanted it. When he had to go to a new situation the animals could go with him, while the plants could not. So the Nomadic stage came in. Sheep and cattle became his companions. Let us see what hereditary traits these animals had that made it possible as well as desirable to keep them about the home.

It seems not unlikely that very early, a sort of half partnership sprang up between the wolf and man. While all this runs far back of record, it is not difficult to imagine the circumstances under which it all occurred. Men and wolves ate the same kind of wild animals, perhaps largely horses and deer. It is not unlikely that man learned to let the wolves tire out and pull down a big animal. Then he, with his clubs and stones, especially the combination of both called a spear, would drive away the wolves from the carcass. When man had taken what he wanted, the wolves, hovering in the offing, closed in and finished up the offal. Man was glad to have them do this. It kept the place more agreeable and though he may not have realized this, more healthful.

I have no doubt, after a time, man by throwing out his refuse, encouraged the wolves to surround his camp. This was an easy way to dispose of offal and it kept the wolves near by. This last was desired, because they howled at the approach of any person straying near the camp, or of any attacking party. Thus they warned man of the approach of the enemy.

The hunter is constantly bringing in the young of animals he kills. They are very appealing both by their helplessness and by their playful ways. Most old people even in the Eastern states can remember seeing brought into captivity a bear cub, a fawn, or the young of the fox, the raccoon and the opossum.

Some of them prove dangerous as they grow older, some of them never get to be quite at home. Others get along comfortably and become pleasant companions.

What were the hereditary endowments of the wolf that made him valuable to man and at the same time led him to submit so completely to domestication?

I think the fundamental fact beyond all others lay in his habit of going with the pack. Whenever animals have this habit, it is a necessary consequence that most of them will submit to the will of the leader. There are few sufficiently dominating to be leaders themselves. Most are followers. Under domestication man is the leader of the dog. It is instinctive in the dog to submit, once the mastery is thoroughly established. So entirely is this the case with the dog that man can train him to restrain almost every other impulse when the master demands it. Hence the dog is more thoroughly domesticated than any other animal friend of man, and he was doubtless man's first friend.

Now a flocking animal must be one which can communicate with his fellows in the pack, either in the way of warning or as summons. Hence, on approach of an outsider, the wolf calls his warning to the pack, and when he sights his prey he summons all the pack to help him in its chase.

Here we have the two great uses for which man took the wolf under his patronage and eventually made a dog of him.

Doubtless the most widespread use of the dog, and the one which almost any variety may serve, is that of a guardian of the women and children at night and in the absence of the men. A dog about the house is one of the best provisions against burglary. Even though it be too small to harm the intruder, it effectually warns the master of his presence.

Another great use is the result of the hunting propensity and of the dog's ability to track his victim by the scent. Man has taught it to follow up his game and then to yield or even to bring it to him.

Just what wild wolf was tamed to make the dog, or whether it was some type we no longer find wild is a question on which zoologists differ widely. The gray wolf of Europe, Asia, and North America is probably the fundamental strain. The jackal of southwestern Asia and India doubtless contributed his share. Perhaps others helped a little. Most modern strains of dogs contain a touch of both.

The dog seems to have early broken into half a dozen fairly distinct types. These, to use favorite examples, are the collies, the grey hounds, the spaniels, the hounds, the bull dogs and the terriers. All the rest seem to be modifications or combinations of these. How largely these six types run back to separate varieties of wolf and how much of the modification has come since domestication it would be hard to tell now. The dog has been man's closest companion amongst the animals and many tribes of men of many minds have had a hand in the breeding

and selection. There are as a result more kinds of dogs than of any other sort of domesticated animals.

Far older than the dog, in contact with man, is the horse. Horse bones, in enormous numbers, are found in connection with man's early remains. But it was as a food supply man used horses for many thousands of years before he thought of domesticating them. When man began to draw pictures on the walls of the cave and on pieces of bone, the horse was a frequent subject. Never in these situations is he represented with man on his back, or indeed with any sort of load. Almost never and if at all only late in the history of the old Stone Age of man is there any bridle or halter. Men of the new stone age which began in Europe about ten thousand years ago took the horse for uses other than food.

It is not long before the value of the horse as a beast of burden is so great that man can no longer afford to eat him.

What were the qualities of this animal that made man take him under his care? He could carry a burden, whether man or load, at a speed nothing else that was willing to serve man could make.

There are clearly three types of wild horses that were captured and used by man. These were the desert horse, the steppe horse and the forest horse. The steppe horse still runs wild in Mongolia. The other two have disappeared from their native haunts and are no longer found wild, though their skeletons and these domesticated descendants are well known.

The largest part of the blood of our present horses is clearly that of the forest horse. The ancestral form is dark, almost black in color and often more or less dap-

pled. He was the largest of the three types and had very heavy legs with fringes of hair on them, and had much mane and tail. We see all these qualities, greatly exaggerated, in the modern Belgians, Percherons and Shire horses. They are the animals that, before the gasoline age, used to draw the fire engines and they were "the brewer's big horses."

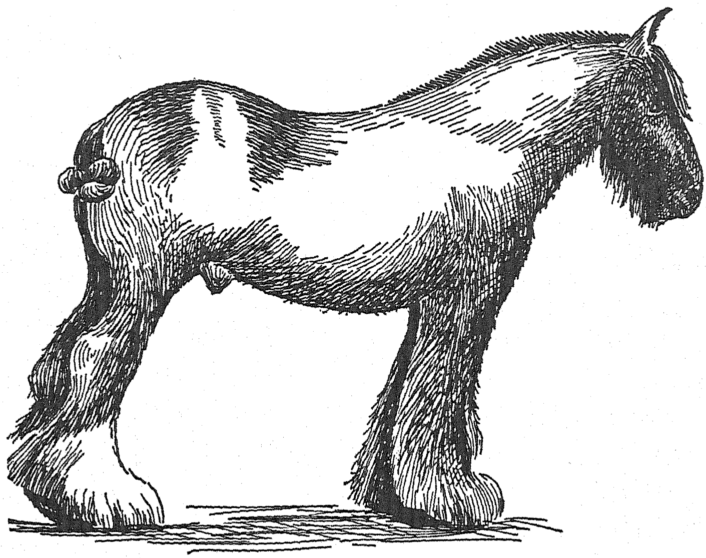


FIG. 17—Descendent of the forest horse, bred for strength.

Into this strain we have introduced the blood of horses which were early used in the countries about the Eastern end of the Mediterranean. They are of the desert strain. The Arab horses are of this type. Their blood, when added, made the descendants of the forest horse both lighter and faster.

When modern racing came, the stock was largely of

this "Arab" breed. Man o' War, probably the greatest American horse of the racing type, has the blood of the three most famous early horses of this strain streaming through his veins. Of the thirty-two ancestors of his fifth generation, twenty-one are said by Mr. Sutherland to go back to Eclipse, nine to Herod, and two to Matchem. It is not hard to see why he is a thoroughbred.

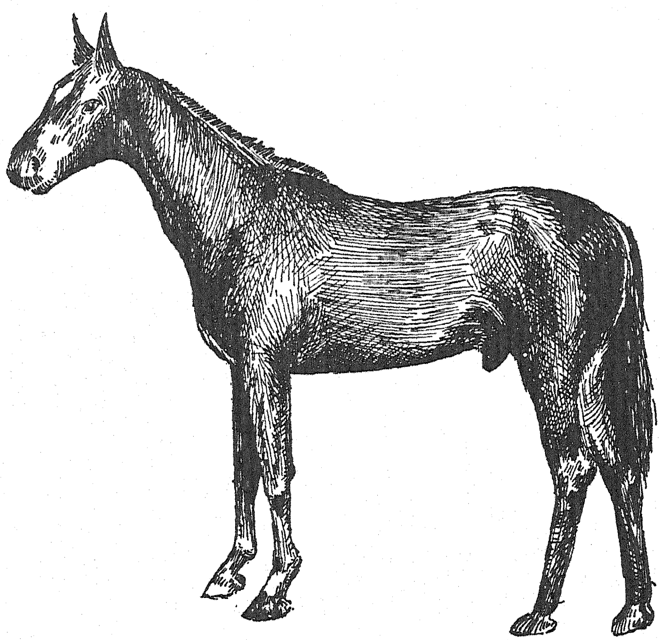


FIG. 18—Descendent of the desert horse, bred for speed.

The steppe horse is the ancestor of our ponies of the Shetland type. The hereditary qualities of these three varieties of the wild horses are still the points that make them useful to man.

The great draft horses, the race horses, and the ponies remain our marked breeds. The majority of our common field horses are of mingled desert and forest breed. Their color comes chiefly from the bay colored desert horse.

Most useful of all the animals domesticated by man, in the long run, are the cattle. None of our present kinds now exists wild. Man early either captured or destroyed the whole species.

Animals of the open plain have no place to hide their young from the sight of their enemies. Accordingly they carry their young inside their bodies longer than other mammals do, whose homes are more secluded. Hence the colt, the calf, and the faun, the lamb, and the kid can all stand and walk at birth, and can take care of themselves soon afterward. Such big animals need much milk.

Man found three desirable traits in the cattle. Always they were a fine source of food. Also in early days they carried and drew heavy loads, though so slowly that the impatient modern has replaced them with the horse or the gasoline car. Likewise, man soon found that if he removed the calf from the cow early the cow would continue to yield her milk for a very considerable time. Beef and milk, the latter including butter and cheese, are what endear the cattle to us.

The wild cattle were evidently small, much smaller than our best stock. What we have done with them in each of two directions is most remarkable. We no longer care for cattle as beasts of burden. The yoke of oxen once served well enough but is entirely too slow for us to-day.

Our wants now are beef and milk. These two are op-

posed to each other. Either the animal puts on much flesh itself, and restricts its milk to the comparatively small amount needed by its own calf, or else it puts its abundant food largely into milk and but little, comparatively, into its own framework. All fine cattle are markedly of one or other of these two types.

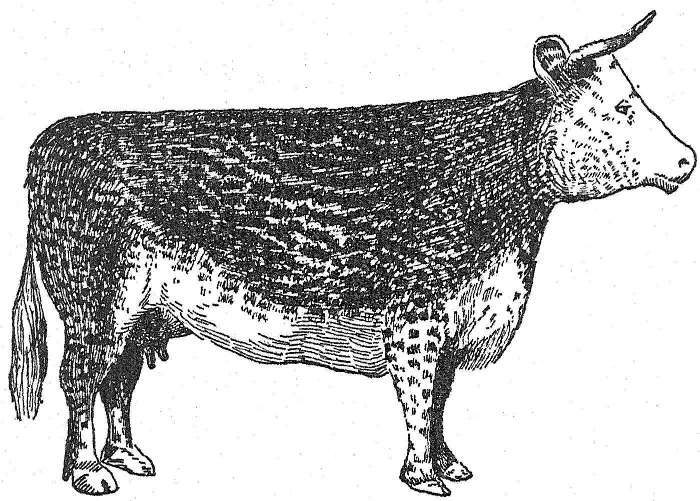


FIG. 19—Beef type of cow, (Hereford) "dolled up" for the show.

The beef types of cattle, (Fig. 19) like the Hereford and the Angus, grow very heavy and much of their weight is seen about the front shoulders. The milk cattle (Fig. 20) are far more graceful. Their weight is concentrated at the rear of the body. Their udders are often enormous and the milk veins on abdomen and udder stand out as thick as a finger. A good Hereford bull will weigh a ton and the cow of the same breed fourteen hundred pounds. A good Guernsey bull weighs but little more than the

Hereford cow, while the Guernsey cow tips the scale at about a thousand pounds.

It is the capacity for producing milk with its valuable content of butter fat that has been most marvelously exaggerated by selection and breeding. It is doubtful whether the milk produced by the wild cattle would have yielded

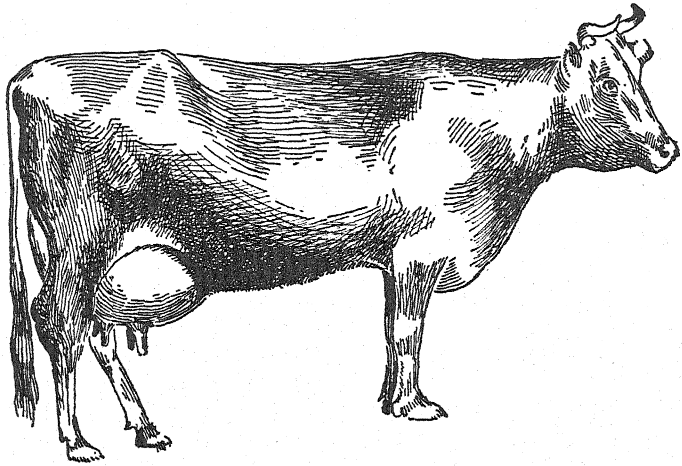


FIG. 20—Milk type of cow (Guernsey).

fifty pounds of butter fat in a year. The old fashioned little red country cow gives about a hundred. A few Guernseys and Holsteins have gone as high as a thousand pounds.

No amount of selection and breeding could have produced such results unless the wild animal taken was accustomed to giving milk for young large in size and long held in the body.

Quite another feature that makes cattle suitable to our purpose is that they are polygamous. As many males are

produced as females. In a state of nature the bulls fight each other, often to the death. The successful male thus gathers about him a herd of females. In domestication we simply save the best males for breeding purposes. By removing the sex glands from the remaining males we used to make them tractable so that they could be used for oxen, in plowing and drawing heavy loads. Now we call them steers, and fatten them for the meat market. The very fact that they have been emasculated makes them put on fat. In addition they are fed heavily, kept in a warm place and exercised only enough for their good health.

There are few animals which man has modified to his own use as thoroughly as he has the chicken.

There are indications that the fowl has had some sort of domestication for more than three thousand years. The original wild bird is the Red Jungle Fowl, still found in Burmah. In size and general character it much resembles a bantam of today. It has much the coloring of the old fashioned red Leghorn. What made it so desirable for man's use? First it is a ground bird. This means that its leg muscles are heavy, while most birds have them very slight. The wings are used by these birds, but not largely. Hence the meat of the breast, which works the wings, is tender and white. Because there is a ground nest not well concealed, the eggs are many to make up for danger of loss, and large, so the young can remain in the egg until they can run. The ground habit also makes it easy to confine these birds. Again these birds are polygamous. The males fight each other for the possession of a group of females. Hence in captivity it is possible to kill off most of the males without dimin-

ishing the fertility of the flock. In addition to all these characters, this bird seems particularly variable, and hence lends itself easily to the influence of man's selection and breeding.

Here, as in the cattle, two types are most common. In its own home, the chief desire of the natives seems to

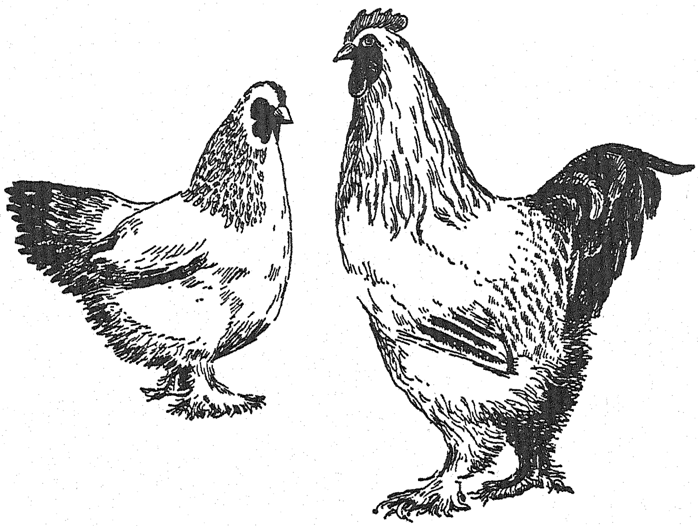


Fig. 21—The Asiatic type of fowl, heavy, for meat.

have been to get as much meat as possible out of the little jungle fowl. Hence they have always selected and bred from their very largest specimens. The result is the Asiatic type, such as the Brahmas and Cochins. While the wild male probably weighed a pound and a half, a fine Brahma will weigh twelve pounds, a marvelous triumph of man's skill in breeding these birds.

Almost any bird can be made to lay a larger number of eggs than usual if the egg be removed after it is laid.

Where this has been done for ages, with the same strain of fowls, the birds come to keep on laying through a large part of the year.

A poor peasantry, who could not afford to eat their fowls, naturally came to breed for large numbers of eggs. In this way there has arisen the Mediterranean class of which the Leghorns are the best known. These had orig-

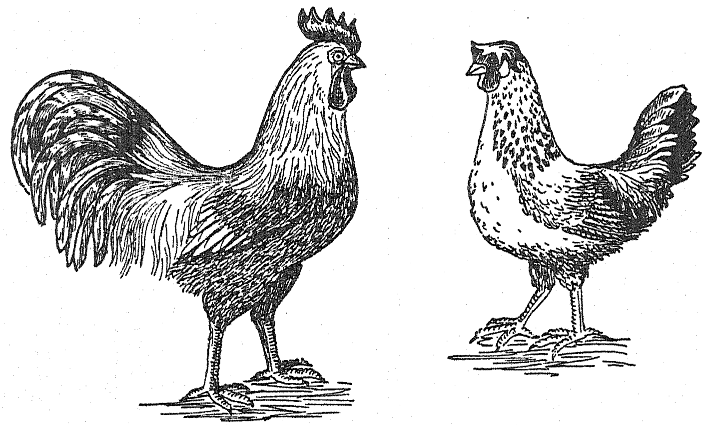


FIG. 22—The Mediterranean type of fowl, light, for eggs.

inally the color of the wild type, but recently fashion has decreed a white fowl to be the most desirable and the Leghorns are now prevailingly white.

This chicken weighs a little less than half what a Brahma does, though, at that, it is three times as heavy as the original fowl. But whereas the wild bird laid perhaps twelve to fifteen eggs, once a year, the average hen in this country lays seventy-five. Some of the best Leghorns lay two hundred eggs within one year. A single fowl has been known to lay three hundred and fifty-one.

The practical American wants to get both meat and eggs from the same fowl. He has tried crossing big birds with good layers and selected the best results for breeding. Perhaps the favorite of these in America has been the Plymouth Rock, though the Rhode Island Red is a close second. England has given us the popular Orpington.

The lesson, on the heredity side, which we may learn from all these examples, is exactly that which we gathered from twins, from peas, guinea pigs, and fruit flies.

Every organism is a mosaic of unit characters. Each of these is dependent, for its presence, on a determiner, or group of determiners, either in the egg which came through the mother or the sperm, furnished through the father. These determine absolutely all the possibilities. But not nearly every possibility or indeed half of them shows in the finished product. In each pair, made up of one from the father and one from the mother, one of the two is more or less fully dominant and the other recessive. Only one of these can show fully. As for the rest, environment must decide. It will stimulate the growth of one quality, and retard the development of another. A quality may be dangerous in one locality, which would be quite helpful in another. In nature the favored ones prevail in the long run and the species changes, usually quite slowly, occasionally by a swifter mutation.

Man by his selection can hasten the process in his domesticated animals and cultivated plants. But his work, quickly done, quickly returns, if he takes his hand away. He gets yellow dogs and little red cows, and mighty common chickens, and slate blue pigeons when he gives his varieties easy access to each other.

CHAPTER VII

SOME INTERESTING FAMILIES

Every now and then circumstances turn up an exhibit for which we are not looking. Material gathered for one purpose serves unexpectedly well the requirements of an entirely different problem. The evidence is all the more valuable because undertaken for a different purpose and hence without bias for or against the question whose solution it later serves.

Back in 1874 the New York Prison Association delegated one of its members, Mr. R. L. Dugdale, to visit prisons of the state and report on the conditions found there. He had not visited many of them before he noticed the same name occurring again and again on the records of six of these institutions. This led him to examine into the circumstances which brought about this result. He was particularly interested in the economic side of the problem, the cost to the state of the maintenance of these people. But it did not take him long to realize that he had hold of a thoroughly degenerate family.

In writing the history of such a set of pitiful characters one may not use their real names or libel suits might easily result. Indeed anyone who describes such a family never does it out of dislike for the family itself. Hence he must use a fictitious name. Colloquially in certain parts of the country, when a boxer, instead

of meeting and parrying the blows of his opponent bends his head and lets the blows pass over him he is said to "juke." Dugdale applied this name to his crowd of degenerates because, confronted by the obligations of daily life, they never met them face to face but juked and let them pass by. So this family came to be known as the "Jukes." Similar groups have been known as "Ishmaelites" and "Pineys." Almost every state in the Union has some of them; older states often have several centers of infection.

In Central New York, by the side of one of those marvelous glacial lakes which are the charm and the pride of the state, lived long ago a woodman known simply as Max. He had a shanty scarcely fit to call a home. Here he lead a life of vagabondage, gathering about him at frequent intervals others of his own worthless kind. Ostensibly they lived by odd jobs and by fishing. As a matter of fact they plundered the neighborhood in a series of small and trivial depredations; a little corn now, some potatoes then, later perhaps an odd chicken. The neighbors had little doubt of what was happening and they suspected who were to blame, but they kept quiet about it. They preferred putting up with the small losses rather than incurring the petty enmity of these people who might easily make serious reprisals if they were disturbed. The farmer is always afraid of fire. His buildings are inflammable to a degree, help is distant, protection small. A determined incendiary can sometimes cause repeated barn fires and entirely escape detection though living under constant suspicion. Fear such as this, all through my childhood, made it possible for bands of gipsies to camp on almost any country farm, even though

the farmer was sure he would be short of corn, potatoes, and general garden stuff, and not unlikely a chicken or two. He hoped by leniency towards small depredations to escape the loss of a horse. The gipsies almost always had with them a horse or two more than were needed to draw their wagons. They were always "trading" horses, and were always suspected, perhaps unjustly, of having come unfairly by some of them.

In similar fashion these woodsmen and lake shore dwellers were more or less protected by the unwillingness of the neighbors to incur their enmity.

Old Max had two sons who married two sisters of their own stamp, perhaps even worse. Dissolute women are often worse than dissolute men. When they give up all hope or expectation of enjoying the respect of their neighbors they seem to "go to pieces." Undoubtedly too, both the members of both families would now be seen to be quite feeble minded—morons at least.

Feeble mindedness is recessive, and if regularly mated to vigorous minded stock the hybrid children are commonly normal, but they convey the feeble minded strain. If they mate with others of their kind the recessive strain is very likely to reappear. Of course if a doubly feeble minded man mates with a doubly feeble minded woman you have a double dose of recessives and the children will all be feeble minded. There can be little doubt, in the light of more recent study, that such a double taint met in the "Jukes" and ruined the stock.

One of the women was herself so vile, and her progeny so terrible that she came to be known as "Margaret the Mother of Criminals." When they gathered the names of collateral families of this stock it was found that not

only the prisons but the alms houses and asylums also had large numbers of the members of the tribe. Dugdale succeeded in tracing twelve hundred descendants of the original four, and he succeeded in getting full details of the general habits of life and of the character of more than seven hundred of them.

There was a startling similarity of history amongst these people. They were all shiftless and idle. They worked no more than was necessary to keep them alive—and often depended entirely on the public for their subsistence. Three hundred and ten of them were supported either in the alms houses or at least by public charity. They were without even common school instruction. No compulsory education law then gathered up the children and compelled them to enter the school room. These children, very many of whom were born out of wedlock, and hence all the more likely to be neglected, ran about picking up a miserable education in shiftlessness and often in debauchery. Three hundred of these children died in infancy—a clear comment on the sort of bringing up they had. Who shall say they and the world were not better for their early slipping away? Fifty of the women of this group were known to be utterly abandoned. Four hundred of the men and women were recorded as seriously affected with social diseases.

There are classes in the world of confirmed and habitual criminals quite as there are in the social world outside. There are the "higher ups" who do the planning. They are rarely caught and when this occurs they have usually means enough to employ the most skillful of those criminal lawyers, practising at the bar of every large city, who by one means or other almost always can bring it about

that their client somehow escapes conviction or at least does not go to jail. If he does, he usually gets out very soon after he is committed. When actually convicted the home of prisoners of this class is usually the United States Penitentiary at Atlanta or at Leavenworth. Of this sort of upper grade criminal there were none amongst the Jukes.

Below this grade is another, where the men are not brainy enough to plan for others, but who themselves work their own plans or are directed by others. They are the adventurers of the underworld. They lead a hectic life full of excitement and abundant danger. They are always lured on by the hopes of a "big haul," though it is the almost universal testimony of any of them who escape long enough to have an extended career that they usually have money to spare for a very short time after a haul. They are often miserably short of funds, and in the long run, they make less than if they had a steady job at fair wages. They dislike regular work and they live in hope. They run into frequent danger of their lives and when caught are usually cynical about it and say it is "all in the game." A few hundred years ago they would have been buccaneers, pirates, and brigands. This is the kind that fills our penitentiaries—state prisons for those guilty of serious and usually repeated crime. There were a few Jukes who rose this high in the criminal social scale. Seven of the Jukes were convicted of murder. Of these, doubtless a few belonged to this second class.

The third class is comprised of those who are simply shiftless, worthless, quarrelsome, and drunken. Often they are of very limited mentality. Without ambition

and without shame, they live a thousand years behind their times, outcasts from a society that has completely outgrown them. Of the one hundred and thirty Jukes who had been convicted of crime, most belonged to this class.

Dugdale estimated that of the twelve hundred members of the family he was able to trace, the average individual had cost the state one thousand dollars, spent in trial, conviction and maintenance in idleness in jail or in care in hospital, asylum or outside relief. The whole tribe had actually cost the state one millon two hundred thousand dollars. Doubtless there was indirect loss in still greater amount. The damage in contamination of the human strain is incalculable.

This account of the Jukes family was well known in penological circles but had produced little effect on the general reading public before an educator of rare insight, Dr. A. E. Winship, who has been for many years the editor of the New England Journal of Education, saw the hopeful side of this apparently hopeless situation. In a charming booklet he gave a summary of Dugdale's findings and then paralleled it with the account of the Edwards family who had done even more to uplift the human strain than the Jukes had done to depress it. He claimed that the potency of good is greater than the potency of evil.

The main street of Northampton, Massachusetts, forks when otherwise it would run through a large and old church. In the second quarter of the eighteenth century Jonathan Edwards gathered here the largest Protestant congregation then within the United States.

Born in 1703, the only boy in a family of eleven chil-

dren, he started at once on a path that led him in a life only moderately long, to an intellectual preëminence in American history shared by very few men indeed.

In his Sophomore year he was not only able to understand but was completely captivated by Locke "On The Human Understanding." He says that he gained from it a pleasure far higher than the greediest miser could enjoy when gathering from discovered treasure handfuls of silver and gold.

He married into another of the great families, the Pierreponts, giving his children a double heritage of uncommon strength.

It seems quite modern to learn that a long and most successful ministry was terminated by the vote of a large majority of the congregation because of the dissatisfaction produced by a sermon of his on the behavior and reading of the young.

His career after his departure from Northampton was pitiful in the extreme. In dire poverty, which was never discovered by others until it was too late, he lived for several years until his strength was pitiably depleted. Then he was elected President of Princeton University. He however had scarcely asumed his duties there when he died because in his weakened condition he was unable to endure an inoculation for smallpox.

Here was a man who poured out year by year a series of writings, philosophical and theological, of the utmost importance to the development of the scholarship of his time. Always of very modest means, he succeeded in giving to his children education and aspirations like his own.

From Jonathan Edwards and Sarah Pierrepont have descended a marvelously fine and important family.

At the time Dr. Winship wrote his booklet he was able to trace a large number of these descendants. He found amongst them two hundred and eighty-five graduates of forty-five American colleges. Thirteen colleges in this country have had at least one president each, out of this family. Sixty-five college professors belonged to this same group. It embraced thirty judges, sixty physicians, one hundred clergymen, and one hundred and twenty lawyers. Eighty men of this descent were elected to positions of political character, three of them being governors of their states. There were to their credit one hundred and thirty-five "books of merit," including those by Winston Churchill.

While there is no possible doubt that there was a very wide difference between the environment in which the young Jukes grew up and that enjoyed by the members of the Edwards family and their descendants, there is equally no doubt that had the surroundings been reversed while the heredities remained the same (an impossible situation) no Jukes would ever have risen to the great prominence of a host of the Edwards tribe nor would there be any question but that many a member of the Edwards group even though so unsuitably surrounded, would have burst through his limitations and risen in spite of conditions.

An even more remarkable paralled has more recently been brought to public attention. The Vineland Training School for Feeble-Minded Children in New Jersey established a research laboratory to study the problems of feeble-mindedness. Supt. E. R. Johnstone called H. H. Goddard to take charge of this work. The fortunate combination

of these two men has made that research laboratory famous. They soon determined that there must be a careful study of the family connections and surroundings of the inmates of that institution before there could be any possible knowledge of the causes of feeble-mindedness. Their visitors soon uncovered an amount of material which made possible Goddard's famous book on "The Kallikak Family."

The story began much like that uncovered by Dugdale. They found in several institutions of various kinds, people of the same name, all pitiably defective and delinquent, like the Jukes. But the startling contrast with that family was that the name here was that of one of the very finest families in the state. As the records grew, it was evident that under this family name there were living in New Jersey a double set of people. The one strain was of the very finest character, the other pitifully obscure. Finally the story unraveled itself. It was a "Kallikak" family; a beautiful-ugly family. Goddard is a literary scholar, as well as scientific, and his fertile imagination combined the Greek words Kallos-beautiful and Kakos-ugly into Kallikak, and used it to designate this astonishing family that might not be faithfully described under its own name.

Says Goddard—"We have here a family of good English blood of the middle class, settling upon the original land purchased from the proprietors of the state in colonial times, and throughout four generations maintaining a reputation for honor and respectability of which they are justly proud. Then a scion of this family, in an unguarded moment, steps aside from the paths of

rectitude and with the help of a feeble-minded girl starts a line of mental defectives that is truly appalling."

During the revolution it was the custom to establish companies of militia to serve as home guards. Martin Kallikak, before he became of age, was a member of such a company. While it was stationed near a country tavern this boy became intimate with a feeble-minded waitress at the inn. Her name is now lost; but she gave birth to a child to whom she gave the name of its father. Martin, Sr., having apparently "sowed his wild oats," prepared to sow a more domesticated crop by marrying into an excellent family. By this wife he had nine fine, clear minded, well reared children. Here is the start of the double line.

Of descendants by the feeble-minded girl there had been traced, up to the time of writing the book, four hundred and eighty people in five generations, ending in Deborah, the Vineland inmate whose case led to the search. She has been under tuition since she was eight years of age. This process has been almost without intellectual results of any kind though with much improvement in her behavior and habits. If her great-great-grand mother was like her, there is little reason to wonder at what happened. Of, perhaps more than ordinarily pleasant appearance, with every passionate impulse of a woman and with entirely insufficient mentality to restrain her, this latest member of the family, if turned loose on the world, would undoubtedly live as her pitiful ancestors have lived for five generations.

Of the four hundred and eighty known connections in the "Kakos" branch, the visitor, trained especially for this work, has found one hundred and forty who are

clearly feeble-minded. Only forty-six, under this careful examination of the individual or if dead of the history, seem clearly to be normal. The rest are either unknown or are the border line cases which must be passed as normal.

By those who study them professionally, feeble-minded subjects are grouped into three classes. If, no matter how old they are actually, their mentality is less than that of a normal child of two years of age, they are known as idiots. When they are mentally like a child of from three to seven, they are called imbeciles. A person with a mind the equivalent to that of a child from eight to twelve years of age often used to pass without much custodial attention. Such people were commonly known as "simple." To these Goddard applied the term "moron." Deborah is a moron.

In the case of thirty-six of this side of the family the parents of the children were not married to each other. Thirty-three of these were prostitutes, who if society had done its duty by them would have been protected from themselves. These feeble-minded people seem to have a strong attraction towards others of their own grade of mentality. Looking over Goddard's pedigree charts we find repeated cases of union with others also known to be feeble-minded. To read the visitor's accounts of the dilapidated homes, the dirty and draggled children, to realize the utterly helplessness of the parents because of their lack of any approach to sex morality, with the consequent frequency of social diseases, is to gaze into depths of which most of us fortunately know nothing whatever.

Meanwhile the "Kallos" half of the family is spreading influences of the finest kind through its native state.

Four hundred and ninety-six members of this side of the Kallikak parallel were traced. This is worthy of attention in itself. From the one feeble-minded son of Martin has come a line of four hundred eighty people, largely degenerate. From his seven children by his fine wife there are in the same time only ten more descendants.

Of the good side of the house the worst that can be said is that two of the men were alcoholic victims and that one of the men was of frankly sexually loose life. The members of this group were the worthy mates of people chosen from the very best families of the state. The men were doctors, lawyers, judges, educators, traders, landholders, in short, respectable citizens, men and women, prominent in every phase of social life. A bible printed in 1704 and owned by the original landholder, Caspar Kallikak, great-grand father of Martin, is still a valued heirloom and in the possession of one of his descendants of the eighth generation.

There is in Goddard's mind no question whatever as to the meaning of this terrible story. There is one overwhelming cause of feeble-mindedness. It may not be absolutely the only cause, but it is so largely the cause that here the problem must be attacked.

If Goddard, and most of his fellow workers on the feeble-minded are right, the damage to such a child is irremediable. You cannot alter a past heredity. You may mask it in part by training, but it is there. Nothing but life long custody is, they say, a satisfactory solution.

There is, it must be said, another and more hopeful group. They are students of the endocrine glands. They believe faulty secretion of these glands, thyroid and others, is the fundamental difficulty in feeble-mindedness.

Sometimes the trouble is due to excessive activity and the remedy is surgical; sometimes it is due to deficiency and the balance must be made up by feeding or injecting preparations from similar glands in animals slaughtered for food.

These men believe they can tell almost on sight of the patient the type of feeble-mindedness and the gland involved. They feel sure they are making distinct improvement in many of their cases and think the time will come when they will help many more. Thus far, I think the group is small and, to the body of their fellows, they seem over hopeful.

These unfortunate feeble-minded individuals, utterly incapable of taking care of themselves, must be cared for by the state. Not only this, the state must assure itself of the certainty of their having no descendants.

The surgeon knows well how with a minimum of inconvenience to the patient during the operation and with no discomfort or emotional alteration afterwards, he may remove the possibility of the fruitfulness of later sexual union. No inconsiderable number of eugenists have suggested such sterilization of the clearly feeble-minded. This solution, it seems to me, is both heartless and dangerous. It turns out men who with full passions and no repressions are a constant menace. It sends out into society women who will be the constant victims of evil minded men. It almost commissions both sexes to spread social disease.

There seems to be but one satisfactory solution of the problem. These helpless creatures must be the wards of the state during their entire lives. Associated in small groups with others of their own grade of mentality, they

lead lives of as near an approach to happiness as their minds can feel. In such cases the boys and girls, for whatever their physical age, mentally they are all boys and girls, are kept in separate parts of the grounds. They are never together except for social or educational purposes when they are in charge of their teachers. They are taught such handwork as their mind permits, which may be quite a little.

The number of these feeble-minded people is so large that the cost of caring for them all seems at first sight entirely prohibitive. An approach to a solution of this part of the problem has been worked out by Superintendent Johnstone of the Vineland Institution. A piece of "pine barren" land was purchased. A leader, and a man and his wife to keep house, took a group of about twenty morons, to live through the summer on this plot. These men were kept at such work as they could do. It took three or four of them to accomplish what one normal minded man could do. They often spoiled materials and sometimes tools. But those who were over them understood them and made the best of all this. A little labor had to be done by healthy men from outside, but unexpectedly little. They cut trees where necessary, they pulled stumps, they graded roads. When they made cement-blocks for building they spoiled a fair proportion, but even so the blocks cost less to make than it would to have bought them, and the patients were happily and healthfully occupied. When the job was done, the ground was so improved that enough money was offered for it to pay the entire cost of the experiment.

If only such methods could be generally used with our dependents, Supt. Johnstone believes these people

could do much for their own support. There is little doubt that criminals in our jails could and would under wise and good management largely support themselves, and be better in health and morale for so doing. Hiring out their labor is undoubtedly unwise and is being gradually abandoned. Thus far the fact that the product made in the jail, enters the market in competition with smiliar articles made by labor outside, has been the chief difficulty. Gradually, however, the plan of making materials for the use of the state itself, in its various institutions, has been gaining in favor both of the authorities and of the labor organizations. A wise and just solution of this problem seems on its way.

Pennsylvania's first forester, Joseph T. Rothrock, was also much interested in the care of tubercular patients. It was his firm conviction that the state could keep all its dependent tuberculars on the forest lands belonging to the state itself. Most of these people, he believed, could be given work entirely within their powers, planting seeds, caring for seedlings, planting out trees, clearing out woodland of its superfluous brush and cutting properly merchantable trees.

He further believed the material sold and the increase in value of forest land so used, would be the entire equivalent of the money spent in the care of these people. Furthermore, many of them, after such a life would in time be restored to health and vigor.

It seems almost Utopian to dream of a time when all the upper type of feeble-minded, all those stricken, but not yet prostrated, by tuberculosis and those who for amendment of their own evil lives and for the safety of society must be withdrawn from free life, should con-

tribute largely, if not fully, to their own support. Yet there are capable men, famous for their studies in each of these departments, who assure us it can be done.

Such institutions, however, must be run with a mind single to the welfare of their inmates and of society. They must be managed by men who are trained, skilful and consecrated to this work. Their helpers must be similarly chosen for their fitness and their devotion to the cause. Is it too much to hope we may some day see this dream come true?

CHAPTER VIII

THE PROBLEM OF ALCOHOL

THERE is perhaps no problem connected with the whole question of heredity and environment, which is more beset with difficulties of every kind than the alcohol problem. Is there any result in the children, of excessive alcoholism on the part of either or of both parents? If so, what is that result? Is it degeneracy of mind or of body in the child? Is it depressed vitality which though evident is remediable? Or is there no result?

The one fundamental difficulty is that the problem is so tied up with our long held opinions and with our emotions that many of us feel our convictions are religious, and hence cannot be mistaken. To doubt them is blameworthy. To hold them open is in itself irreligious. We are so convinced of the righteousness of our cause that we are anxious to emphasize everything that looks in our direction and to set aside everything that looks as if it might point the other way.

So it is very difficult, quite as hard today as it has been at any time for years, to approach this question with calmness of mind and with willingness to accept the results of the observations or of the experiments undertaken to solve this question.

But granted a calmness of mind that is willing to accept the result obtained, there still remains a serious difficulty.

Alcoholism is tied up with so many other things, carelessness, indifference, poverty, with its accompanying inadequate housing, clothing, and food that it is exceedingly difficult to separate out the effect of the alcohol from all the rest. It is this that throws possible question on the conclusions of physicians and social workers.

In this, as in so many human questions which are biological in their character, there is the possibility of arranging experiments on lower animals, and concluding from them what would be the result if one could with propriety perform the same sort of experiments with human beings.

When one comes to look over the record of those who have been led to express their opinion, based on their own observation, the result is almost disheartening. The conclusions are often exactly opposed. Under these circumstances it is almost futile for one who, like myself, has had no personal contact with the result in any such quantity as to give me a right to an opinion based on my own observation, to pass on my own impressions. I think however I see a slow diminution of one kind of opinion, that was once nearly universal. At the same time I find a corresponding increase in the clearness with which other men are voicing a somewhat different interpretation of the same facts. So I shall venture to try to portray this gradual alteration in the attitude of many scientific men to the problem of the relation between parental alcoholism and filial degeneracy.

Amongst the earlier men who have written on eugenics is one, to whose opinion the scientific world has always paid reasonable attention, the Englishman, Saleeby. He is very clear and definite in his statements as to the effects

of what he calls the racial poisons. He seems to have been much impressed by the report of a physician concerning lead workers. There is a distinct sort of poisoning that comes to workers in lead who are not carefully guarded against its dangers. It appears that house painters are particularly likely to suffer from lead poisoning. The children of women who work in lead factories are said to be the serious victims of the lead poisoning. Miscarriages, abortions, sickly and even idiotic children were said to be common with both English and French mothers who work in lead factories. He even reports serious results with children whose fathers only, worked in lead.

With this "poison" Saleeby links a number of others, dwelling particularly on alcohol and syphilis.

He is firmly convinced that nervous degeneracy in children even to feeble mindedness and insanity, together with general lack of vitality is the common result of alcoholism in the parents. While he quite understands that the mother with her pregnancy may have a much longer chance to do injury to the child than the father, whose contact with the germ cell ceases with the fertilization, he insists on the deleterious effect on the child of drunkenness on the part of the father. When both parents are alcoholic the results are intensified. Miscarriages, still births, deformities, insanity, feeble mindedness and epilepsy seem to him due to alcohol more than to any other one agency.

This strong position of Saleeby's has doubtless had much to do with the general attitude of the older eugenists to the problem. A Norwegian physician, Mjöen, also gave data that seemed to point in the same direction. He states that for nearly twenty years, in the earlier part of

the last century, anyone in Norway was permitted to distill his own liquors. This seems to have resulted in a very much more common and excessive use of alcoholic beverages than was the case previously or later. Mjöen says these same years saw a marked increase in the amount of idiocy in Norway which at once receded when the state again undertook to regulate the manufacture of alcoholic liquors.

Of the same general and rather indefinite character, but with other conclusions is the evidence of a Scotch physician, Tredgold. He reports the conditions in a Scotch seaside village whose men are practically all fishermen, who leave with the fleet and are gone from home for a considerable fishing season. He says that the return of the fleet and the fishermen is (or then was) the occasion for some days of universal drunkenness. But he clearly reports that the children born nine months after such return showed no difference from children conceived in the same village at other seasons, when, he says, such conditions did not exist.

All of this is the earlier story. This was followed by rather simply devised experiments, growing more critical as time progressed.

Laitinen gave food moistened with a certain amount of alcohol, to part of a group of rabbits in one experiment, and guinea pigs in another. He said there were more still born progeny where the parents had been fed alcohol, and the young who lived, grew more slowly than was the case with those whose parents had no alcohol.

Hodge tried the effect of continued alcoholic feeding on a pair of Cocker Spaniels. He kept them in a state of almost constant intoxication. A friend of mine who

helped him in the experiment said the dogs were constantly "dopey." After a time it was almost impossible to persuade them to mate, so indifferent had they become.

This pair were mated repeatedly until they had produced twenty-three pups. Of these, nine were born dead, eight were more or less "deformed" and only four lived to grow up.

During the same time another pair of similar dogs were also repeatedly mated. They produced forty-five pups of whom four were deformed, none were born dead, and forty-one of them lived to grow to some size.

Still later Stockard undertook a different plan. First of all he selected his guinea pigs, and mated them and found them and their progeny to be quite normal. Then once a day for six days of the week he penned them up in an atmosphere saturated with alcohol. He assured himself that the ordinary respiration process furnished these pigs enough alcohol, by absorption into the blood in the lungs, to produce distinct intoxication. This process was kept up for more than two years. Repeated matings of these intoxicated creatures produced a large batch of offspring. They were quite markedly defective in comparison with normal matings. There was an unusual number of sterile matings, half again as many were aborted, five times as many were born dead, only half as many survived the difficulties of early life. Stockard says of them "when the reproductive organs and germ cells become injured in this way (by alcohol) they give rise to offspring showing weak and degenerative conditions of a general nature." "The next generation of offspring are equally weak and injured." In the face of all this it seems almost impossible to doubt the very serious

effect on the children of alcoholism of the parents. And yet there are some things to make us pause.

Pearl tried the same sort of experiments with chickens with the strange result that the offspring of the alcoholized fowls were somewhat more vigorous than those from normal chicks. The peculiar effect under the conditions was that the proportion of fertile eggs was reduced. Pearl does not think Stockard's results are negatived. Guinea pigs undoubtedly show the result reported. In chickens alcohol in the parents seems to weed out weak offspring early, leaving only those particularly fit to survive.

Several other men working on rats and on mice came to much the same conclusion as Pearl, namely that week strains died under the influence of alcohol particularly in the mother, but that those who were able to survive it were naturally strong. Of course there is no thought that alcohol made them strong, it only killed off the weak.

Galton, the Englishman, was one of the earliest modern students of heredity. He coined the term eugenics as the science of developing a fine human race by bringing about the judicious choice of mates. At his death he bequeathed funds for the formation of the Galton Research Laboratory for the investigation of problems in heredity and in eugenics. This work is now carried on under the leadership of Karl Pearson.

Sometime ago, research workers under this foundation undertook the solution of one phase of the alcohol problem. Judging that the school attendance record of children would on the whole be a fair indication of their health, these investigators worked out a health index for each child in the schools of a large manufacturing district. Then they endeavored to find the alcohol record of the

parents of these children. They seem not to have tried to separate total abstainers from moderate users and these from parents who drank heavily. The distinction they drew was between those who "had bouts" and those who did not. I think by "had bouts" they meant that these people, though perhaps drinking little as a general thing, periodically were overcome and became for some days utterly intoxicated.

Working on this basis, they could find no traceable difference in the health of the children of the two classes. Of course statistics never come out exactly even. They would be suspected of being forced if they did. Strange to say the small and entirely unsuggestive difference was in favor of the side who had the bouts. This result, though the work seemed well done, was so unexpected and so at variance with general opinion that the institution determined to make wider, fuller, and if possible more critical research. If the results of the later work have been published, the fact has not come under my notice.

It may not be amiss to narrate the incident which started the doubt in my own mind whether the earlier conclusions had been far reaching enough. On my earliest visit to the Vineland Institution for the training of the feeble minded, I was strongly impressed both by the character of the inmates and by the intelligence with which they were handled. After making the round of the place I asked Superintendent Johnstone "How many of these people are here as the result of alcoholism on the part of their parents?" He had been so prompt and definite in his replies to so wide a range of questions before that it surprised me to hear him say, "Frankly, I do not know." My first interpretation of the statement was that it was not

their custom to record any data of this sort. Then he added "I am beginning to wonder whether we do not have that problem just turned around. Is the alcoholism of the parent the evidence of the degeneracy of the strain which shows itself in the feeble mindedness of the children?" I went away with that thought lying in the background of my mind. Again and again it has seemed to interpret apparently irreconcilable results of two different workers.

Some years later Goddard published his "Feeble Mindedness," based on the case histories of the inmates of this same institution. I think this book is generally regarded as the best attempt to solve the question of the cause of feeble mindedness. His book abounds in family trees of the inmates of the institution and the pages are spotted with the symbols of people of the same family who are feeble minded, or epileptic or died in infancy or are sexually degenerate or are serious alcoholics. He is definitely of the opinion that alcoholism is quite as much a symptom as it is a cause.

After remarking "if alcohol did cause feeble mindedness, the number of the feeble minded would be enormously greater than it is now," Goddard says "Indeed one may say without fear of dispute that more people are alcoholic because they are feeble minded than vice versa."

May we come to a few cautious conclusions? The occurrence in the same individual, of pauperism, misery, alcoholism, vice and feeble mindedness is very common. While anyone of them may possibly be found without the rest, the farther down we go in the order named the more likely we are to have them all. The one which would be sure to produce the rest would certainly be feeble mindedness, if the person were left to his own devices. Is not

each one of the others a possible, indeed probable, symptom of feeble mindedness? Does not the occurrence of any two of the others make it probable, and of any three make it almost certain there is feeble mindedness?

I do not, of course, mean that everyone who uses alcohol is feeble minded. What I mean is that anyone, who, seeing where alcohol is taking him, and wishing to refrain still finds himself overcome is almost certainly to some degree feeble minded. Such a person is not an assuring husband nor is he a safe father of one's children. If the same failing is present on both sides, the danger is very great. It makes no practical difference whether alcoholism in the parent produces feeble mindedness in the children or if the alcoholism is a symptom of feeble mindedness in the parent that may easily appear in the children or (if existing only on one side) in the grand children. For man or woman to take as one's life partner a mate already showing an inability to control a fondness for alcohol is to go openly into very serious danger.

I should like to make another reference to the heredity side of the problem. Will the children of parents with an "appetite for alcohol" inherit that appetite? I think the answer is also reasonably clear. If the appetite for alcohol is merely an acquired habit, which, if the owner really wanted to, he could restrain, then there will be no actual inheritance of the appetite. If however, there be the "irresistible impulse" at times, then the feebleness of will, which makes resistance vain, may indeed be inherited and in the children may make resistance also very difficult if not impossible. Again, if this appear only on one side it may act as a recessive trait and remain quite unmarked in the children but appear in the grand children. And

again, if it be present in both parents it is most likely to appear in the children. Where there is such parentage the utmost care should be exercised to keep such children away from all contact with alcohol, whatever be the opinion of the parents or guardians as to the propriety or impropriety of its even moderate use.

CHAPTER IX

DO WE INHERIT DISEASE?

WE INHERENTLY expect things to go right. Generally they do go right. Of all the things that happen in the day it is safe to say that ninety-five per cent are sure to go well. Indeed if you break your day up into very small actions ninety-nine per cent of them go right. Certainly if you count all the times you cross a room, you get across without the shadow of a mischance more than ninety-nine per cent of the times. Only once in a great while does the rug beneath your feet slip on a newly polished floor and bring you down. Rarely do you trip on an unexpected object. Now and then you bump into something and bruise your skin. All the times you go safely make no impression on you compared with the time you slipped on the rug or stumbled over a hassock or bumped into the square corner of the arm of the mission chair. So all the days in which you go comfortably from morning to night, with every organ, so far as you can tell, doing its duty fully and faithfully make little impression on you. Is that not what they should do?

Unconsciously you take it for granted that they are working as they are made to work. Your auto is far less complicated than your body, and is used in a far smaller variety of operations, but it needs to go to the garage for repairs far oftener than most of you go to the

doctor. You forget on how many days you go well all day, and you remember in undue prominence the day your tooth ached or your stomach rebelled or a headache warned you of some forgotten folly.

In exactly similar fashion the interested person who undertakes to read up the literature of heredity will be apt to get the impression that it is chiefly deformity and disease that we inherit, when as a matter of fact it is overwhelmingly the good factors that are passed on from father to son.

Is disease inherited? We must guard against two possibilities of misunderstanding here. What is disease? What do we mean by inherit? If we are not agreed upon our use of these two words we will find it unlikely that we give the same answer to the original question.

It is not hard to tell what is to most people, the phase of disease which most impresses them. It is the discomfort produced, the lack of ease, *dis*-ease. As a matter of fact it is this feature which is ordinarily the big blessing connected with an otherwise injurious malady. The lack of ease, the discomfort, often the severe pain, is nature's benevolent warning that things are going not quite well. Were it not for the discomfort of our maladies we would let fatal disorder creep over us practically unnoticed. Pain is the message of an injured or disordered part of the body, sent to the main office, the brain, saying that something needs attention. If the message is not insistent most of us pay little notice to it. Ordinarily the attention is given if the discomfort is moderately great, and some remedial, or supposedly remedial, treatment is given. If the pain is very great it is not uncommon to simply blot it out with a narcotic. This often

deceives the brain into thinking that something is being done, when the only result is that the messenger has been silenced, and the message is unheeded. So we take a headache powder, or a dose of paregoric or rub the part with menthol and quiet the announcer. Sometimes before we recover from the effects of the narcotic the body has repaired its own disorder, but the narcotic had nothing to do with the healing. What should be done is to try to find why the head ached. Is it eye strain? This is not cured by headache powder. It needs glasses, or new glasses or better light or better position. Is it overwork? Headache powder does not help this. It is rest and freedom from worry one needs. Is it disordered digestion? Headache powders do not help this. It needs better discretion in the choice of food or time or method of eating. The headache is disease, lack of ease, to warn us of disorder, lack of order.

So let us, in looking for the answer to our questions as to the inheritance of disease forget the lack of ease and pay attention to lack of order. In this sense then disease is some lack of adjustment on the part of the body which makes it unable to fully cope with the demands the environment puts upon it.

How far is malformation a disease? We usually use the word deformity for serious deviations from the normal plainly visible from the outside. But the line is often thin between this and disease. A malformed valve in the heart will be spoken of as a structural heart disease, while the failure of the heart to pump regularly, may have no visible malformation connected with it. We call it a functional heart disease. But there must be some malformation or misconnection in nerve center or elsewhere which

causes the irregular command that results in the "irritable" heart.

Deformities of some kinds are peculiarly heritable. This probably means that in the crossing of the parents these traits are dominant. It is not very unusual to find a person who has "six fingers." The X-ray tells us what has happened. One of the long bones running to one of the fingers has branched into a Y. Why it did so is hard to tell. It was not an accident during development. The trouble lies back in the chromosome. For this sort of six fingeredness (polydactylism) is quite heritable.

Normally the thumb of the human hand has two joints while the fingers have three. There must be a gene in the chromosome that causes this difference. But sometimes there must be a new gene arrangement by which the fingers only have two joints in them. The subject has "short-fingeredness" (brachydactylism), and this also is hereditary.

Now let us take a malformation of a very different kind. Some years ago I was delivering a series of public lectures involving heredity. The man who was in charge of the hall had one pitifully small arm and hand. I should say it would have weighed less than one third as much as its mate. My talks on heredity led him to tell me about himself. He was born with a smaller arm, and as he grew up it lagged more and more behind. When he came to manhood and the question of marriage naturally arose, he hesitated long before allowing himself to hope. He was deterred by the fear of bringing into the world children who might suffer the inconvenience, and no little sense of inferiority, from which he had suffered during all his younger life. Then he went to the Medical School of the

University of Pennsylvania and consulted their appropriate specialists as to the advisability of his being married. They told him not to hestitate. That his malformation was due to the fact that before birth something had compressed the budding limb. Probably it had become entangled in a turn of the cord through which the growing child drew its nourishment from the mother. This was purely an accident of development, not due to any fault of his own inheritance and would not be passed on to his children. Relieved, he went home and was married. The result justified the advice. He had a number of children, five as I remember, all finely grown, some of whom had children of their own. On none of these was there any sign of deformity. Of course one case is not conclusive. This is cited not as proof, but as an example under a well understood law.

Certain types of deformities then lie in the germ plasm and may be handed on. Even here they may be recessive and never appear before they are bred out. Inbreeding, that is marriage with cousins, makes them twice as likely to be present in the strain, though not nearly so probably as that to show, should they be recessive characters.

But these cases after all are very few. The great mass of conspicuous malformations are accidents of embryonic development or of after growth and are not destined to appear in the later family. Particularly, any result of an accident is no more likely to appear in children born after the accident than in those born before the mischance. Disfigurement, of the mother, for instance, as the result of a burn, will have no influence whatever upon her subsequent children. These things are acquired characters and they are not transmitted.

Now to come to abnormal conditions that are clearly to be recognized as disease. There are certain functional diseases, where organs do not act well because they have been used either too little, too much, or unwisely. Let us take the general and indefinite disorder of the digestive system which is known as chronic indigestion. This is doubtless due to any of various causes. Sometimes the misused part is not the alimentary canal. But I suppose it is most commonly due to indiscretion of living of some sort. If so it will not be transmitted; but the child may easily inherit the liability to give way at the same spot under the same sort of indiscretion. Hence the child of parents so afflicted should be more than commonly careful to guard against the mistakes of living that are of the kind which result in the sort of weakness feared.

The boy whose father and grandfather dies of "heart failure" will if he be wise see that his exercise be graded so as to strengthen the heart, and take all ordinary precaution against having the strain on that organ suddenly increased. But unless in the case mentioned the person can do all this without anxiety and without depression it were better he forget it entirely, even though eventually the heart should fail. It is far better to live a life free from fear even though it terminate somewhat early, than to lengthen out a little longer a life of anxiety. It is foolish to make life miserable in order to prolong it.

It is only since the day of Louis Pasteur that we have come to realize the real cause of most of our diseases. If we could cut out entirely infantile indigestion, tuberculosis, mumps, measles, scarlet fever, pus infections, diphtheria, pneumonia, malaria, and the social infections, life would be materially lengthened and made much more

happy. All of these diseases are clearly and unmistakably due to organisms from outside which have invaded the body. In almost every case, there is a single sort of organism which is responsible for the disease. In pneumonia there seem to be about four kinds of bacteria which are concerned, but each is responsible for its own type of pneumonia and only one of them seems necessarily fatal. In pus infections there seem to be at least two or three types of bacteria any of which can multiply under the surface of the human body and stir the system up to sending abundant blood to the spot thus causing inflammation. At the same time this blood places there white corpuscles which multiply rapidly enough to make the otherwise clear fluid in the cavity quite creamy. It is the waste products, poisons, toxins, excreted by the bacteria which produce the bad effects on the body.

In tuberculosis, whether in the glands of the neck, the lungs, the joints, or the intestines, there is just one kind of bacillus (rod shaped bacterium) which is the cause of the trouble. Another bacillus causes diphtheria, still another, typhoid. Malaria is also caused by a minute parasite (a one-celled animal in this case) which is introduced into the human body by a mosquito of a special type (not the commonest kind by any means). This insect gathered the parasite from a preceding malarial patient, and carried it through a complicated transformation inside its own body, before sending it on into a new victim.

It is clear that such disorders, and they are the main troubles we group under the name of disease, are not due in any direct way to the nucleus of the egg or of the

sperm cells. They are acquired characters, if anything ever is. Being such they are certainly not inherited.

That is they are not inherited in the sense in which the modern scientific student of heredity understands that word. But there is a common sense of the word in which some of these are inherited. Let us see whether we can not make this distinction clear.

I inherited two different sorts of things from my father. Let me name one of each kind, and this will help us to understand the difference between the scientist's limitation of the word, and its significance in ordinary language. I inherited from my father a beautiful copy of the Revised New Testament. It has a special binding and inscription, of a kind made only for the scholars who had been members of the committee of Revision. The daughter of one of these revisers inherited it from her father. She gave it to my father, and I inherited it from him.

Again; I inherited from my father his iron gray hair.

My father owned the book up to the time of his death. After his death it came to me. When he had it, I did not have it. When I had it, he did not. No one can misunderstand what I mean by the word when I say I inherited this book from my father.

On the other hand, and in the scientist's sense, I inherited from my father his iron gray hair. But my father's hair did not leave him at his death and come to me. I lived many years and had my own hair, while he was still alive and had all his own hair. When I arrived in the open world I had mighty little hair and what I had was flaxen white. Soon it grew brown, for a while threatening to get quite ruddy. Then it settled down to

be iron gray. When I was quite grown it was very like my father's even to a flare. That is to say, as the hair began to grow gray, in each of our cases, there was a patch running from the parting towards the middle of the head, which grew gray faster than the rest. Here is clearly a case of inheritance in the scientific sense of the word. That is to say, in the single sperm cell, by which my father transferred to me the half of my hereditary acquisitions of which he was the vehicle, there was a particular gene in a chromosome, or a group of them, which determined that my hair should develop as it did. But this gene was descended directly from a gene that was twin brother to one in the egg from which my father developed and which decided that his hair should grow as it did.

Heredity then, in the scientific sense, brings about that similarity between parent and offspring, which is due to the fact that one gene in the fertilized egg from which the parent grew up split into two. One of these, lying in the part of the egg which developed into the father's body, determined the character of his hair. The other lying in the part of the egg which was the new germ plasm, multiplied, retaining its exact constitution until it appeared unaltered in the fertilized egg from which the offspring developed.

Now in this scientific sense, no germ disease, and that embraces most of our diseases, can possibly be hereditary. There can be no difference of opinion, so far as I can see, on this question.

It not infrequently happens that if a mother has a disease (this is particularly true of syphilis) when her child is born it is infected with the same kind of organism

and sometimes to an advanced degree. Indeed not uncommonly the embryo dies before birth, clearly as a result of the seriousness of the infection.

Now ordinarily people would say this child had inherited the disease from its mother. Not a few physicians would say the same thing. In the ordinary sense of the word this is perhaps true. But as a matter of fact, in the strict scientific sense it is not true. The child might have been born quite free from the disease and after birth contracted it by contact with the mother. This would be recognized by everybody as an infection. But it is quite as much an infection if the child has caught the disease from the mother while growing up within her body. Such a child does not inherit the disease, it contracts it. If physicians were careful in the use of the term, and they are growing steadily more so, they would call this disease "congenital" but they would not say it was "inherited."

There are very few diseases that are even "congenital." Diphtheria is not, though it was long thought to be. The child born of a diphtheritic mother is free from diphtheria at birth, but is uncommonly susceptible to the infection from the mother. If however it be promptly and thoroughly isolated from the case, both from mother and attendants on the mother, there is no reason why the child should have diphtheria. It is also true, strange to relate, that though the mother's blood may have a full dose of antitoxin, either self grown or taken from a horse and injected by the physician, the child will have no antitoxin in its blood and will not be immune.

There is a very strong belief on the part of many

people that tuberculosis is heritable. What is there to give rise to this opinion?

In my childhood I knew of a family which seemed to show this most thoroughly. They were people of education, refinement with means enough to employ a good physician, and with disposition to carry out his instructions. The father, a professional man, died of tuberculosis after a lengthened illness. There was a family of perhaps half a dozen children. At first they seemed to show no trace of the disease, which was not then known to be recognizable by bacteriological means. As the children grew up, each was "seized." Few of them lived to be twenty-one and none of them got much beyond that. The mother nursed and buried them all, without incurring the disease. She lived to old age after they were all gone. This certainly seemed to be hereditary tuberculosis. To-day it is likely, were that same case to be repeated in an equally intelligent family, the father would quite possibly be saved and the children certainly would be. Tuberculosis is not hereditary. It is doubtful if, except in very rare types when the uterus of the mother is itself the seat of a tubercular sore, tuberculosis is even congenital.

Why then does it "run in families?" If it does, something is inherited. In the next chapter we shall speak of immunity. Some people seem able to bear contact with infected patients, and not take the disease, though many people under the same conditions would be sure to be infected. This sort of immunity seems to be heritable—though this is not demonstrably certain. If such natural immunity is transmissible, we would naturally infer that it might be equally heritable to be unable to resist infec-

tion. If this inability is serious, it might be almost as had as to be infected. For every one becomes infected with the bacillus of tuberculosis at times. Most of us have now and then a mild infection with this germ and throw it off without realizing anything more than an ordinary cold. Hence if one inherits an inability to fight off tubercular infection he is in a bad way. But if he knows himself to be a member of a tubercular family, he should be most careful to avoid all known infections and especially to keep his body in the very best of health. It is in our moments of weariness and of depression that our bodies fight least vigorously against invading germs.

There is one more disease which is not uncommonly believed to be heritable and that is cancer. This is said to "run in families." The truth is it is so common that there are few families in which a careful hunt through the connection will not disclose a few cases. This makes it hard to decide whether it is heritable. But there is enough evidence to cause suspicion.

There is probably no other source of disease so common of which the medical world knows so little about the circumstances which bring it about. No one knows how to guard against it, except by precautions that would set most of the world needlessly guarding against the disease. This the medical world knows. Cures would be twice or three times as abundant as they now are, if the cases had been brought to the attention of a specialist the moment there was a consciousness of any growth, or hardening, or continuous sore. Radium and x-ray may be valuable in mild cases, especially if on the surface, but the surgical world will feel surest of a cure if the affected part and its immediately adjacent apparently healthy tis-

sue is removed. Done early, this need not be a serious matter. Left late, it may be without avail.

Much time and money and many good men are now being turned on the cancer problem. Any day may find it answered. Every now and then someone announces that he has found the cause and devised a remedy. Hope springs up but thus far has always died away again. The early knife in the hands of a skilled surgeon is, to-day, the safest remedy.

CHAPTER X

DO WE INHERIT HEALTH?

THERE is probably no single phrase that has ever arisen in biological study which has gained such wide use and such general acceptance as has "the survival of the fittest." When Darwin brought out the idea in connection with his work on the "Origin of Species" he called it "natural selection." Wallace, whose paper was read with Darwin's at the famous meeting of the Linnaean Society, in 1858, called the same concept "the struggle for existence." Herbert Spencer, the philosopher of the movement, coined the pregnant phrase "the survival of the fittest."

While some of the later evolutionists have doubted whether this process may be counted as an effective cause of evolution, no one doubts that this natural selection is going on all through the plant and animal worlds.

To help us understand this principle a few illustrations will not be amiss. Each spring there comes back to us from the sunnier south a wave of bird life. It brings on its early fringes the robins. Back to our trees they come, often the same robins to the same trees. A robin with a single white feather in one of his wings came several years in succession to the same tree near my home.

Often repairing the same nest they set to work again rearing first one brood and later a second. Usually the mother bird began to warm the eggs with her body when

she had laid four. It was common for all of them to hatch. Occasionally one failed to yield its little bird. But one by one they disappeared. Perhaps the eager persistence of his brothers and sisters gave them all the food and before his mother realized it he starved under her eyes. Another perhaps did not obey well enough the cuddling habit, and dropped over the edge of the nest. Another did not know when to keep quiet and in the dusk a screech owl lifted it out. One only got big enough to follow its mother from the nest and be fed on the ground. Usually the cat got that one. Probably a good old pair of robins, who fulfill the robin destiny have put four eggs into the nest twice a year for four years. They have started thirty-two young lives. On the average, by the time the parents themselves drop out, two of the thirty-two have been reared to maturity and have done their own mating and egg laying. If more won out the number of robins would increase. As a matter of fact, these birds may be a little more abundant one season and a little less another. On the average the number remains about the same. The unending struggle for existence is too much for most of them and they slip out young.

The same is true of all animals whose numbers remain about the same. Our commonest red-legged grasshopper abundant everywhere in summer and fall on our lawns and in the pasture fields, lays its eggs in the late summer and fall. It commonly puts two packets of eggs into the earth with about thirty eggs in each packet. This is the last duty the mother can perform. Her husband is already dead; now she too dies. The eggs are not buried deeply. They lie almost at the surface. Lots of entire packets must be tramped to death by animals, especially

cattle. Chickens, bob-white, meadow larks, all must scratch up and eat an abundance of them.

It may be that some of these eggs are more sensitive to cold than the rest and the freezing of winter is too much for them. Others are too obedient to the call of spring, perhaps constitutionally, perhaps because they were put into too sunny a spot. These develop before the young grass has sprouted. The old grass is too tough for the weak jaws of young grasshoppers and they die for lack of food. Others come too late—and again the grass is too tough and they die. All this has gone on for ages and most grasshopper mothers have been the descendants of those who laid their eggs properly, and they too, do the same. Most eggs come through grasshoppers who hatched on time, and these eggs hatch on time themselves. Most baby grasshoppers came from parents who kept very quiet in the face of danger until they saw it inevitable and then rapidly jumped, and when they landed slipped a little to the side of the spot where they lighted. The young, or most of them, do the same. Even with all this, of the sixty each year, fifty-eight on the average must fail, and two only live to mate and in turn start two batches of eggs. When more succeed, grasshoppers become a plague. Nature must then take care of that. Their enemies gather; new enemies arise until the number is brought back to the old level.

When the grasshoppers thrived so heartily, on the new ground plowed and harrowed by the Mormon immigrants on the Salt Lake Valley, that it seemed the crops would entirely disappear, the gulls came, as if in answer to the piteous prayers of the settlers, and devoured the grass-

hoppers. So the gull is almost the Patron Saint of the Mormon.

Nor is this any less true in the case of the human race. The girl who has prepared herself to teach only to find when her course in complete that there are more girls ready than there are positions open in the neighborhood, has seen the struggle at work. The unskillful stenographer in a busy office, who finds herself the one dropped when business grows dull, realizes with terrible distinctness that she is not the fittest there, and does not survive in that environment.

When we pick up the local newspaper and glance down the column of death notices unconsciously we are reading the names of those who for some reason or other could not cope with their environment. Fittest in this sense does not mean morally best. It only means best adapted to meet the demands of life in their surroundings.

Some of those who died had battled long before they succumbed; but the fight grew fainter and fainter and finally they could no longer resist. It is not tragic. It is simply inevitable and as old age comes on we all expect it. These die of old age; that is of generally weakened powers, though usually one organ, weaker than another, gives way first.

The next is perhaps a death as the consequence of having been struck by an automobile. It is not unlikely that a slow invasion of the eustachian tube by bacteria of the throat had made hearing less keen. There was no "honk" and the ear was not sharp enough to hear the more quiet approach of the car.

Or perhaps the person was incautious and stepped suddenly into the path of a rapidly passing auto. One must

now be very alert if he means to cross the road or he is at any time liable to find himself amongst the unadapted.

Perhaps the person who drove was intoxicated, or reckless. Still when we realize there is the possibility of such people we are on our guard, if we are the very fittest, and will not be taken unawares.

Another died of typhoid. Many others drank the same water or the same milk and did not die. But this one had a lowered resistance, or did not naturally manufacture his own immunity. So he fell when others fought through. They were "fitter to survive."

Still another dies of Bright's disease—whose presence had hardly been realized until within the last few weeks. But a bad attack of measles in childhood had thrown the skin out of commission and overloaded the kidneys. They still worked on and the child did not know they were weakened. But they will not last out a full life.

Another died very unexpectedly of heart failure. He had valves that did not meet exactly and the blood leaked back a little at each beat. Enough went on for all ordinary purposes. Sometimes he gasped under heavy exertion and probably thought he was getting too fat. But less and less strain was necessary, as days went on, to back up the stream and finally it stopped. His heart was not as fit as the rest of him.

So the struggle for life is constantly picking out for survival those who are best adjusted, and setting aside those whose adaptation is less perfect. Friends may cushion the shock, hospitals may surround the person with a less exacting environment but eventually all of us meet the final battle. Of course it is well we should. Who would want a longer period of getting older, and feebler

and more forgetful and less interested, and perhaps more selfish and peevish. All of these are most likely to come with extreme age.

Now what I want particularly to bring out as a result of all this is that our ancestors were those who at least were able to battle with all these conditions until they had reached the marrying and childbearing age or we would not ourselves be here. The great probability is that they reached that time of life bravely, strongly, heartily, or they would have feared to marry and undertake the work and care, though of course also the delight, of a family. They were well—not perfectly well—not absolutely well—but on the whole, well. We are likely to be like them; that is we have a right to expect to be well; not perfectly well; not absolutely well; but, on the whole, well.

That is to say, for the great number of us, our heredity is such and the conditions are such that if our parents and guardians are wise in dealing with us when we are young, and we are judicious in caring for ourselves as we grow older, the long chance is that we will be splendidly well. Health is our heritage.

There are some few (very few) hereditary diseases, but they are the diseases of old age. They allow us to live our lives in part, and bring into the world some children. If they did not, they could not be hereditary. There would be no one to inherit them. So there are some strains living on through the years that have a defect at least bad enough to carry them off earlier than the rest.

But it is the well, the brave, the happy, who face life unflinchingly, that leave the splendid families of hearty children. These do far more than their share of deter-

mining the character of the next generation. So the child comes on finely, and would live finely and go off the stage finely, if it were not for the changing environment. The growth of factory work has changed all the habits of mankind. It has crowded us into cities where it is harder to get fresh water and fresh food and work in the open air, and it has put us into crowded homes by night and crowded workshops by day. The result is of course serious, but we are fast learning our lesson. Conditions of both home and work are rapidly growing more wholesome.

Even man himself can become more tolerant of city crowding. The Jew, who has for many centuries been crowded shamefully into the ghetto, has had the strains that could not stand this sort of life killed off relentlessly. Now when he comes to East Side of New York he finds the crowding far less fatal to him than it is to the Irish. They lived through the centuries in the humble cottage, warmed by an open hearth, which, whatever its defects certainly ventilated the home.

City life is so hard on us that we have been forced to make it wholesome. Fresh air is so hard to get that the law will not allow us to build homes where the provision for air and sunlight is insufficient. In the country each man builds his home to suit himself. In the city fresh clean water is naturally very hard to get. As a result so much attention is paid to it that the humblest apartment in most big cities has in it much safer drinking water than does the average country home. The results of insufficient care in disposing of wastes are so disastrous that the sewage and garbage of a big city meet far better care than one individual out of ten in a country

home thinks of giving them. Sanitation grows up in the cities and only slowly creeps out into the country.

I think then the case is good, we inherit health. But what is health? It is the state of body in which we are hale, whole. It is the ability to heal ourselves, by our own internal powers.

It is often noticed that longevity "runs in families," that is, is hereditary. It is not long life that is inherited, it is fine health, and long life is the by-product.

What is it that keeps life from being long? What cuts it off before the natural time? And how does the successful life beat off these attacks and see itself through to a late end?

Accidents seem hardest to account for. The very name implies that they fall without our will or desert or power to evade. Yet some people have lots of accidents. They fall down stairs or into the bath tub or out of bed. Other people never seem to have these mischances. Instead of blaming the former and praising the latter we "bless our lucky stars" or "knock wood."

Now the people who hear well certainly have less accidents than those whose hearing is poor; those with keen eyes have less casualties than those whose sight is defective; those who by nature move promptly, than those who are slow in reacting; those who are careful have less mischance than those who are careless; collected people have fewer accidents than those who are emotional.

So it comes that in the long run, there are always in the next generation enough people who are sharp of ear, keen of sight, alert, careful and collected, to take the place of their predecessors with the same effective characteristics. Other things being equal, these are the long lived people.

And they pass on their traits, and the world of mankind will grow better in these respects as time goes on or they will organize themselves so that some of the community will do for all what it becomes unnecessary for each man to do for himself. These qualities may only disappear when life is quite secure without them. With organization all may be safer than any can be alone. When a lecturer who is a great scientific explorer and adventurer was asked by one of his audience whether he did not feel fear under the condition he had just described, and which filled his auditors with terror when he related them, his humorous reply was "Madam, the only time I remember being really afraid, in recent years, was in crossing the street at Forty-second Street and Fifth Avenue."

This alertness in time of danger is not all there is to longevity. In spite of all watchfulness and care there are times when things "happen" so far as we are concerned. Somehow there is an accident and the unfortunate victim gets a wound. That is, an opening is made through the skin. What now happens in the case of the man with whom longevity runs in the family? The blood flows freely at first, and if the wound is not too severe, and dirt or clothing has not been forced into it, this gentle stream will at least in large part cleanse the wound of the bacteria that got in. Then the blood begins to thicken and runs slowly. Part of the clear fluid of the blood gets stringy. If the person knew what was coming and was active in trying to ward it off, the probability is the adrenal glands have thrown a messenger into the blood and made it clot more promptly and thoroughly. This clot filled the open space in the wound, if it is not too large. Then it hardened into a scab and carefully covered the fresh

surface and prevented further infection. Now the white corpuscles of the blood creep out through the walls of the capillaries that are unbroken and they actually eat up what is left of the infecting germs. If the cut is small the muscle cells multiply and make the connection. The nerve cells do the same and so do the capillaries. If the

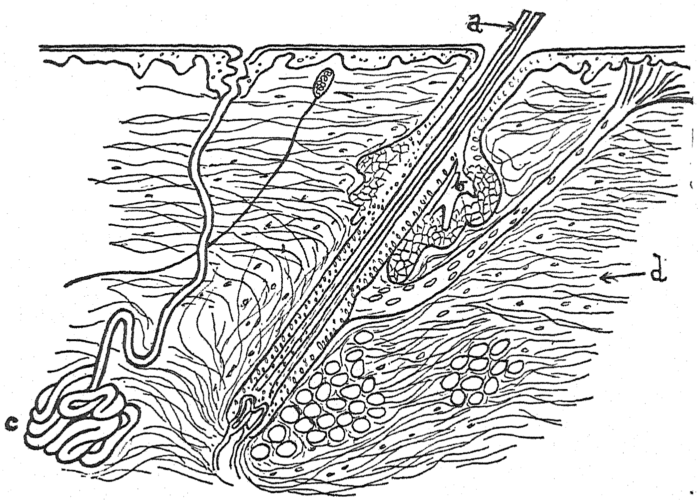


FIG. 23—Section through human skin. *a*—Hair; *b*—Oil gland, emptying into hair sac; *c*—Sweat gland; *d*—Connective tissue.

wound is too serious for this, the connective tissue grows out and fills the opening and binds the parts together with tough scab tissue.

The skin is perforated with many small openings. These are the pores, or openings on the surface, of the oil glands (in the hair sacs) and of the sweat glands. Because the human hair has so nearly disappeared, oil glands are not as necessary as they once were, and many, at the

base of small weak hairs are almost inactive. Pus germs get back into these and start up infections, resulting in pimples. If the white corpuscles do not promptly clear out this infection and the person is not exceedingly clean, the infection is forced out of one hair sac into the next and soon there is a crop of pimples. If one is well and strong and keeps his skin clean, pimples are few.

The sweat glands are pouring out their fluid—a rather acid fluid—with a more abundant flow than comes from the oil glands. Hence these are less likely to be invaded by pus germs. When they are they lead the infection much farther into the skin and the battle is more severe and is known as a boil. Here the white corpuscles must surround the infected spot and, eating the live adjacent tissue they cut loose the infected part. Then they eat their way to the top (the boil heads) and make an opening in the skin through which the detached mass (the core) escapes. Now the adjacent cells begin their multiplication and fill up the hole. Whether the old kind of tissues shall be replaced or scar tissue fill it completely depends on the seriousness of the infection and the consequent size of the cavity.

When the infection begins to break away from one of the glands, it wanders amongst the strands of connective tissue between the muscles and nerves and a wider area becomes affected. Reaching towards the top a number of openings are made and the affection is called a carbuncle. These three disorders are produced by pus infections getting into the skin. But many of us have few pimples, a rare boil and no carbuncles. Others have abundant crops of the first, many of the second, and now and then the third. There is no skin on which the pus germs, at least

a few of them, may not commonly be found. Cleanliness has much to do with skin clearness. But entrance must be not uncommon with us all. With those whose blood corpuscles are sufficient in number and kind, and active, the infection is over before it is noticed. This sort of alertness of blood is doubtless also hereditary and conduces to longevity.

Now we must return to the question of immunity. Some people take an infectious disease with very little contact, while others, just as thoroughly exposed to it go on with entire safety. A series of cases of typhoid in a city, all prove to be located on a certain milk route. Search of the farm from which this milk comes discloses a case of typhoid whose wastes are carelessly handled. Here is the center of infection. The milk is the carrier of the disease. But hundreds of people use that milk; only half a dozen or so get typhoid from it. Why do not the rest catch it? They are somehow immune. Some have had typhoid moderately recently and "will not take it again." One or two, perhaps careful travelers, have been innoculated against typhoid. But most of them simply escape. Either they are naturally immune or they manufacture their own immunity in their own blood.

In what does this immunity consist? The first line of defense lies almost certainly in the previously mentioned power of the white corpuscles to actually eat up the bacteria which cause the infection. There are four or five kinds of white corpuscles in our blood, and each doubtless has its own work to do. The particular corpuscles that devour bacteria are called "eating cells" (phagocytes). But the activity of the blood does not end here. The invading bacteria secrete from their bodies poisons which

alter the surrounding tissues so as to better fit them to be a home suitable to these bacteria. These poisons stimulate the neighboring cells to pour into the blood substances (antitoxins) that start up a resistance to the toxins, and if successful completely neutralize these bacterial poisons. Now the disease wanes and the surrounding tissue starts on its way to recovery. Sometimes the blood already has substances (opsonins) that at once correct some diseases. Various bloods differ much in this as in many other respects. That is why they must always test the two bloods before they transfuse the blood from one person into the veins of another. If they mix bloods of different kinds the result might easily be very serious if not fatal.

Now this "natural immunity" is very heritable. As a result, the race has, through ages, lost in early life the people who do not have at least enough of this quality to weaken the effect of all diseases common to the race. These are the infectious diseases of childhood.

Measles is one of the most common of them. All of us have some blood resistance to measles. Hence it is a disease of which, for a long time no one was at all afraid. Its course is natural, the body immunity is promptly added to and the disease is ended. Indeed the immunity thus produced lasts for a very long time. Accordingly those who have once had measles are not likely to suffer from them again, though they may.

But measles, to people who are of a race unaccustomed to it, is by no means so innocent a disease. About the middle of the last century the "King and Queen" of the Sandwich Islands visited England. The traditions and customs of royalty demanded that these two be royally entertained. While they were the guests of the King and

Queen of England they contracted measles, and though naturally strong and hearty, they suffered almost fatally from the disease.

In 1846 a single case of measles went into the Faroe Islands, which lie far out in the Atlantic nearly half way between Scotland and Iceland. Here a sturdy race of fisher folk live most healthy lives, toughened by a severe climate and the strenuous life of the fisherman. The diseases of more crowded sections ordinarily pass them by. Within a year the intruding infection had spread until three fourths of the population had had measles and "many" of them died. There was no inherited racial immunity.

In 1875 measles was carried by sailors into the Fiji Islands. These again had a population which at that time had had little contact with the outer world and its diseases. One fourth of the inhabitants of the islands died of the disease. The rest were so much weakened that Harrison Allen, a distinguished student of human skulls who had done much work in the island once told me he thought he could tell by the general character of the skull, especially by the form of the dental arch, whether the disinterred skull came from the man who had died before or after the incursion of the measles.

I have not the slightest doubt that tuberculosis, bad as it now is, would be far more fatal than it is, were we not the descendants of those who had repeatedly beaten off the disease. We have a racial immunity, at least partial, to tuberculosis.

I feel quite sure we have also a partial racial immunity to alcohol. Our ancestors used it, and used it abundantly. Especially European peoples have been great users of

alcohol, and the farther north they lived the stronger the drinks they used. Our colonial ancestors would have considered a total abstainer as a strangely unsocial creature and excessive social drinking was far from uncommon.

Enough surely were killed by alcohol. But when the North American Indian first got hold of "fire water" it played far sadder havoc with him than it did with his white brother. He was not racially accustomed to it.

There is still another type of safeguard against disaster on the part of the body. When an engineer builds a bridge he always works with a large safety factor. That is to say, in calcualting the thickness of beam, girder, cable, needed he always supposes the bridge is to carry far more than it is intended it ever shall. Then if, by accident it becomes overloaded, or if there be somewhere an unnoticed, perhaps unnoticeable, defect in some structure, the neighboring parts will be sufficiently overweight to counterbalance the deficiency in the faulty part.

So the human body has a marvelous safety factor. The digestive system is arranged to have food delivered to its care three times a day. It will accommodate itself to a "two meal fad." It will often tolerate a week's fast, if one goes about it judiciously. It will even put up, under need, with still longer abstinence, and then, if gradually set to work, will soon catch up again.

Meanwhile in the absence of fresh food the liver gradually throws its rich store of liver sugar (glycogen) into the blood. At the same time a part of the fat tucked away about the internal organs and between the muscles and under the skin is reabsorbed into the blood and burnt.

On the other hand, if too much food is taken in, the canal leaves part of it undigested and more unabsorbed.

If there is still excess it is stored away as fat. Either way, the amount of food in the blood is kept almost exactly constant.

Again, the body must be kept at a uniform temperature. If it gets too cold the skin leaves the exposed surface until the burning processes of the body have brought the temperature up to the normal 98.6 degrees Fahrenheit. On the other hand, should exercise give too much heat, the blood flows to the surface. If this is not enough to cool it, perspiration is poured out on the surface. This, by its evaporation abstracts heat from the body. When the temperature is reduced to the normal the perspiration ceases, the blood retreats and all is once more natural.

If one begins unaccustomed work with a hand tool the epidermis is rubbed loose from the dermis of his hand and serum fills the cavity. He has a blister. But keep up the work and the epidermus toughens and thickens and becomes more adherent, and all is well. The child who runs barefooted in spring has much difficulty until the epidermis adapts itself to the new demand; then he runs blithely over rough ground.

If, as age comes on, the arteries grow harder and less yielding, the wall of the heart grows heavier to meet the increased work it has to do.

If by surgical operation one kidney is removed the other begins to enlarge and grow more active and is soon doing the work of two. Every phase of this adaptation goes on better when the man is well and strong and hearty. As long as there are wholesome conditions and abundant work the course of life is glorious.

When the body is not well used, it grows weaker. If

used beyond its powers it grows weary and depressed. Under either of these conditions, none of the compensations and corrections and immunities which have been described work as well as they should.

The physician who, at the outbreak of an epidemic hurries untiringly, and safely from case to case, if the trouble lasts long enough, grows utterly weary, his defense breaks down and he is himself the victim.

As Woods Hutchinson put it, the rich have more diseases than the poor because they have more time to enjoy them.

It is then our heritage to be well. It is natural for us to be well. Almost all the wild animals are well. Few of them die of old age, but few of them are sick. They die of accident, or as the quick victims of preying animals.

If we will live up to this, our natural heritage, we will almost surely be well. If we do not do the foolish things we almost all know to be bad, we will usually be well. The great stimuli to such living are abundant work, better in the open air, alternating with sufficient rest, and of that sleep that knits the raveled sleeve of care. Add to these an abundance of simple food and of good clean water, the latter used inside the body and out, and plenty of sunshine. Given these, and all of them are within the reach of anyone who reads this book, and life is nearly sure to be fine and strong and hearty.

If there be disease, it will likely be well and promptly met and recovery is probable. If there be wound there will be quick repair. Eventually of course the end comes. Some weakening of the long used powers will take place

and life ends. But it ends nicely, finely, with quiet acquiescence. A life well lived closes with good cheer and a hopeful outlook.

> "This is the gospel of labor;
>   Hear it, ye men of the Kirk:
> The God of Love came down from above
>   To be with the men that work."

CHAPTER XI

IS CRIMINALITY INHERITED?

We have become very sensitive, in America, to the entire criminal question. We realize that our homicide record is bad, very bad, in every way. Nearly half our murderers escape detection. Of those apprehended many stave off trial for a long time and finally escape punishment, while not more than one in twenty is executed for his crime. We realize that there is something very wrong somewhere, and we suspect there are many points at which the wrong exists. Meanwhile, there seems no possible doubt that the bulk of crime is steadily increasing. At first we thought it was only apparent increase, due to more activity in making arrests, and holding for causes that would earlier have gone unnoticed, but I think practically everybody connected with the detection and punishment of crime has given up that explanation. For a time, after the Volstead act, arrests for drunkenness fell off rapidly, but in the large cities these cases are catching up to the old record, and the crimes connected with "bootlegging" of liquor more than make up the list.

In New York State a new law making life sentences obligatory after a series of convictions lessened the cases there. But even there the downward trend seems to have been checked, and a rise appears on its way.

This increase in criminality naturally stimulates our

interest in the question as to how far the individual is responsible and how far society deserves the blame for his offense.

Beyond this, we are growing more humane in our handling of any people who need custodial care. Whipping was a common punishment for wrong doing. It was particularly used at sea, where autocratic rule of the captain seems almost essential. Yet every civilized navy, I think, has abolished the lash on government vessels. I only know of one of our states whose officers are empowered to whip criminals, and it is not often done in that case, though the whipping post still stands on the capitol grounds.

With this increasing humanity in our care of our less fortunate fellow men, it is not unnatural that the question should arise as to whether we are dealing properly with our convicted criminals.

I think no one who is at all interested in the betterment of his fellowmen, and whose life work has nothing to do with the detection and punishment of crime can go through a great penitentiary without a strong sense that the men are getting what no sensitive man can well stand and retain, or ever regain his own self respect. This is particularly true if the visitor comes into contact with the "cooler," that part of the jail reserved for the punishment of those who break the laws of the jail itself.

On the other hand those whose business brings them into daily contact with the men in the jail are very likely to come to feel almost callous to their needs. These men have done wrong, often very grevious wrong. They have had no consideration whatever for their victims. They have perhaps brutally beaten helpless women and old

men, who had done them no harm. Why should one show them consideration? On many occasions these men have made murderous assaults on their keepers and are likely to do so whenever an opportunity arises. It seems to these officers of the law who have apprehended, or prosecuted, or are carrying out the sentence of the court, that these criminals are almost below the the level of men. Their animal natures are on top and one must treat them almost like animals.

The first sort of people think the second kind brutal. The second kind think the first weakly sentimental. When these two kinds must share the handling of criminals the first always insist that the prisoners must be treated more like men. The second insist that the first would make "molly coddles" out of the prisoners.

In considering then the question as to whether criminality is hereditary it will be well to look into the two sides of the present contest amongst those who have charge of our prisons.

The idea of hereditary criminality as a thought out system dates back to Lomboroso, an Italian student of abnormal man. The general public thirty years ago knew this author quite well because of his theory that the genius amongst men is an abnormality and is very closely allied to the insane.

Amongst criminologists however, Lomboroso is even better know for his book on what he called in Italian, "the delinquent man," but the English translation of his book is simply, "The Criminal." This student went up and down the prisons of Italy examining the inmates. His investigations led him to a firmly fixed conclusion which he expressed clearly and defended vigorously. His view

was that there is a very distinct criminal type. Such a man has marked characteristics. His head is narrow from side to side, which however is not criminal but Mediterranean. His eyebrows cover ridges in the skull that protrude as a heavy shelf. His lower jaw is square and projects forward, his teeth sloping frontwards instead of being erect. The hair of his head is abundant, rather stiff and quite unruly, not lying well after being brushed and combed. He has very scanty hair on the face, neither moustache nor beard being luxuriant. His cheek bones are prominent and quite high. His ears are large and stand out from his head. Mentally he is stupid, often leaving his tracks easily detected after engaging in crime. He boasts constantly of things in which the ordinary man would take little pride. In talking, he is likely to eke out poor power of expression with much gesticulation. He constantly adorns himself with tattooing, his various escapades, sexual or criminal, being more or less celebrated by the tattooed memorials on his chest and arms. Lomboroso accounts for all this on the basis that he is a throw back, "a savage born into modern civilization."

At first the clearness of the description rather captivated criminologists and they were inclined, especially in England, to pay considerable regard to Lomboroso.

The French however combated the idea of the hereditary criminal, from the first. They were strictly believers in the power of the environment. According to their theories, the man who was poor, and grew up amongst criminals naturally became a criminal. Had he been reared in more prosperous surroundings and amongst people of upright life, he would have come out as right as they.

Criminology in America is not particularly well devel-

oped, and what little we have is rather recent. Prison administration is too largely political here to be scientific. There are a few men who have given much time and thought to the matter, and some of the men, appointed originally for political reasons, have grown thoughtful and earnest in the work.

Amongst these men there is little tendency to regard Lomboroso's work seriously. While there are doubtless many men in jail with the physical and mental characteristics, he describes there are also many with the same peculiarities in any large congregation. I was told by a Professor in one of our largest universities that there was scarcely a member of that faculty who did not show at least one of these characters and some of them showed several.

Another friend of mine, while in the university was a member of the class of one of our most prominent American anthropologists. This lecturer described to his students Lomboroso's type. Then he facetiously said, "Boys, if you have five of these characters you cannot escape a life of crime." The boys laughed more uproariously than he expected for they had counted on him, as he lectured, six of Lomboroso's "stigmata of the criminal."

My own interest in the prisons and prisoners dates back about ten years. At that time I spent several weeks during the summer in the city of Auburn, New York. There it was my rare good fortune to meet and know and intensely to admire the late Thomas Mott Osborne. I had an exceedingly favorable chance to see the Penitentiary there and to know some of the officers of the "Mutual Welfare League." I had a memorable hour with "Canada Blackie," the most remarkable of the men redeemed by Osborne.

It is fashion amongst prison authorities to laugh at Osborne as a sentimentalist. I suspect American prisons will never again treat prisoners quite as badly as many of them did before Tom Osborne did his work at Auburn and Sing Sing.

I think no one can visit the "cooler" as they commonly call the dark cells where men are fed on bread and water and not feel that the punishment is terribly brutal. A man who goes there for punishment never goes for his own good. Those who put him there do so for vengeance or out of fear. Almost any man comes out broken in spirit and sometimes insane.

The answer of the authorities is that no man gets there who is not a brute; but there never was a more apparent brute than Blackie, nor a finer fellow after Osborne took him out of the cooler and made him a member of the League.

The spirit in which men are met is a tremendous determiner of their own attitude. In the Rocky Mountains of Colorado I saw a road builder's camp made of tents. The workmen themselves were in ordinary working clothes and the foreman in charge of them had no evident arms, I think was quite unarmed. I was surprised to learn that these men were trusted prisoners from the state penitentiary.

In one of the upper southern states I saw another gang. They were in striped suits, and some of them had the ball and chain on their legs. At night they slept in wagons built exactly like menagerie wagons, built to hold the wild animals, that accompany the circus. Here on shelves these men slept at night, with padlocks on the doors.

Still farther south I saw men working in a line on the

public road. All had striped suits, most of them had ball and chain. At each end of the line stood a guard with a rifle on his arm. I suspect no man on either of the last two sets ever regained his self respect. I equally suspect almost every member of the first set got back to society inclined to try to make a real man of himself.

The difficulty with the Mutual Welfare League, the self-government plan Osborne introduced into Auburn and Sing Sing, is that it takes a man of his magnetism and personal devotion to serve as the mainspring. The ordinary warden has neither the willingness nor the personality to carry it off.

Furthermore, so long as the appointment of the officers is simply the reward of political service, and worse still, when the treatment they give a prisoner depends on his ability to pay, or on his political pull, there can be little really effective work done. All of this however is steadily improving; or was until the bootlegging business became so profitable that its rewards are undermining the morale of our local constabulary, and even the administration of Justice in some of the magistrate courts. It looks as if the revolt against this state of affairs is at hand and once more interested men can apply themselves to the prison problem with some hope of effect.

Is the criminal tainted with a hereditary blight which renders him helpless? Is he a man who is in most respects like the rest of us, but who has been exposed to more need and greater temptation then he could withstand? It was heavier indeed than all but the strongest would have been able to undergo and come out victorious.

In the first case, he must be protected from himself and society must be protected against him.

In the second case, he must be made to see his mistakes, to want to do better; and then he must be helped by the conditions of his imprisonment to regain his self control.

Which of these two is the case? Or do some men fall under the first class and others under the second?

My own experience is very limited, but one visit to the Tombs prison in New York had in it a most significant incident. I had the good fortune to make the acquaintance of the Head Chaplain of all the New York City prisons. He offered to take me through this particularly interesting prison. As we went along, I was, because of being with him, privileged to talk to anyone I wanted to. Mostly I preferred to let him do the talking since the men responded more freely to him. As he conversed with the men, I looked them over. We went up to the second tier of one cell block and taking the cells in order, as I looked into the first cell I said to myself, "That fellow is feeble minded." I was at that time quite in the way of seeing at Vineland the feeble minded, and while I was no expert, I had more than the ordinary man's opportunity to cultivate my judgment.

Passing to the next cell, again this man struck me the same way. I was not yet surprised. But when the third man also seemed feeble minded, it began to startle me. The fourth cell held a man who looked to me quite normal, but the fifth again impressed me as mentally below par. Just then the Chaplain turned to me and said, "I forgot to tell you, this is homicide row." There may have been more homicides awaiting trial. The Tombs is a detention prison for men accused but not yet convicted. But of these five, murderers, I feel reasonably sure that four

were of low grade mentally; having mentality lower than that of a twelve year old child.

Society may decide whether or not a murderer shall be put off the earth. But if she decides he may stay on here, then four of those men had proved that they must be kept always where they could not again take life.

An alienist of my acquaintance had the opportunity of making an unsuspected inspection of a considerable number of prostitutes in one section of one of our big cities. He told me he believed sixty per cent of them were feeble minded. I believe hereditary feeble mindedness has been mistaken for hereditary criminality. I suspect much of my opinion has been tinged by my contact with Mr. Osborne, but I have gone into a number of penitentiaries, including two of the very largest, and many of our county jails. My own conviction is clear.

Many feeble minded people are engaged in criminal occupations, and are not responsible enough to be punished. They should be kept separate, worked in the open air, fed wholesomely but simply and the two sexes not be permitted to mingle.

The mentality of the prisoners in a county jail ordinarily averages quite low, though not low enough to be called feeble minded. The jail experience may scare them straight, much as a boy may be set straight by being spanked by parent or teacher, though there is ordinarily a better way.

I am convinced that the inmates of our large penitentiaries grade rather higher mentally, then the run of equally educated people outside. They can do right, if you can get them to really want to. They have quite mind enough to he held responsible for their behavior. These

men should be divided into classes. Those who are in jail for the first time should be in a different institution, or if this be not possible, in a totally separate part of the institution, run with a distinct purpose to redeem them and send them back into society self respecting, and industrious. The old offenders should be carefully examined as to their mental and moral power. The feeble minded must be treated as those unfortunates are, without self determination and without pampering.

The others, who have mentality enough but just will not go straight must be handled very much on old fashioned prison lines.

It may seem very presumptuous for one not an expert and not deeply trained in these matters to venture an opinion. However our prison practice is admittedly bad; it needs very marked improvement. Under these circumstances all suggestion by anyone who has really cared to thoughtfully study any aspect of the question may reasonably be heard.

PART II

PARENTHOOD

CHAPTER I

THE BEGINNINGS OF PARENTHOOD

KANT, in his philosophy used to tell of certain pairs of ideas which he called antinomies. The two members of the pair were opposites and yet you could not think of either of them. One of them concerned the duration of time. You cannot think of time as having a beginning, and yet you can't but feel everything must have begun sometime. You cannot think of time as ending, and yet it seems as if everything has to end if only you wait long enough. So the scientist cannot feel that life always existed, nor can he easily bring himself to think of living matter as having been "created out of lifeless matter" even by God. The scientists idea is creation by evolution; not without God, but he thinks this is God's method of creation.

Should living matter be evolved out of lifeless, the process would be called spontaneous generation. It must have been a very gradual process. Lifeless matter (inorganic) "must have" grown more and more complicated, until finally it "passed into" very lowly living matter. All of which he has no particular grounds for thinking except that on his theory he cannot think otherwise. Conclusive evidence is entirely lacking.

It is a fundamental presumption of science that anything which has once happened, will happen again, should

the precise conditions reappear. It may be these cannot reappear. It may be that past history is a part of the condition, and cannot again be the same, if only because more history has been added to it. Every now and then someone thinks he has seen evidence of such appearance of life where all was previously non-living. Burke had his "radiobes" that proved to be bubbles of hydrogen in gelatine. Bastian had his molds that be believed grew up in sterile solutions. But he has never been able to persuade the world that his solutions were sterile. The whole science of bacteriology is based on the idea that in properly sterilized media, kept out of contact with the outside, nothing can ever grow. Should the scientist find at any time an unexpected growth, his first suspicion would always be that his solutions were not sterile, or his apparatus was itself infected. Only the most positive reappearance of the phenomena, reproduced at will, would satisfy the present day biologist that life now ever comes from anything but similar antecedent life. And yet, if life ever began, it came out of non-living matter. The only evidence for spontaneous generation is the presence of life on the globe.

Some of the lowliest forms of life can go into condensed and encased forms which we usually call spores. These are very minute and very resistant to cold and heat. It is the ingenious idea of the Swedish chemist, Arrhenius, that interstellar space has these spores floating in it, driven hither and yon by the impact of the light waves. It is his idea that whenever a heavenly body is in proper condition, lowly life is sure to be driven upon it from space. This must then spring up and evolve in directions controlled by the environment it there finds.

We have only one real means now of judging what early

life was like and that is by examining low present life, in the belief it has advanced but little. This may be a gratuitous supposition, but it is inevitable.

Quite the lowliest organization known to the biologist is the amoeba. Life lower than this can scarcely be imagined. It seems only a structureless mass of protoplasm with a single nucleus and no cell wall. Its shape is absolutely indefinite and changes constantly. There is no head nor tail, no right or left, no top or bottom. There is no mouth, no organs of locomotion, no digestive apparatus. Yet its nucleus is quite well organized and when this cell divides into two, it goes through the process of chromosome partition described in a previous chapter.

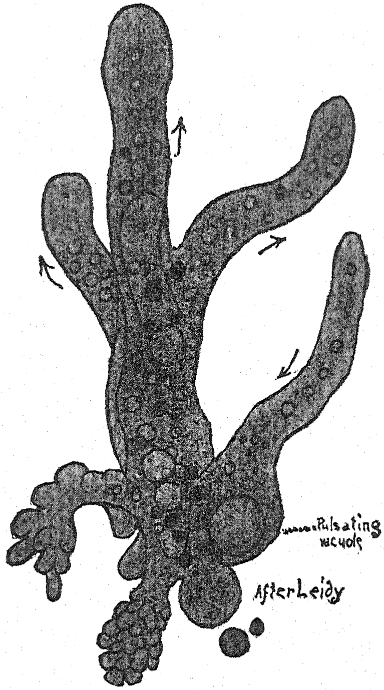


FIG. 24—Amoeba, a very simple, perhaps degenerate animal.

Wherever there is standing water and vegetation and open air and sunlight we may, but are not sure to, find this lowly animal. By taking with a spoon the light, fluffy deposit on the bottom of the shallow pool, we are apt to get it. It is too small to see; so we skim the likely spots and

put the gathered material into glass vessels. These are then taken home and the contents examined under a microscope. The creature when found is usually one one hundredth of an inch or less in diameter. It is quite colorless and transparent. Its shape is slowly and continuously altering. It seems to stretch out a part of itself (a pseudopod) and then the rest of the body flows into this extended portion and a slight change of position has been effected. When it encounters anything it seems to start to flow around it and engulf it. If however the particle is useless it discovers this, probably by a sort of sense of taste, and it withdraws itself and moves elsewhere. If the particle is edible it is completely engulfed. The ingested particle slowly moves about the inside of the creature while the digestible portions are being dissolved. This is the simplest sort of digestion. Now and then a clear drop seems to collect and grow large (vacuole). Then it slowly contracts and disappears. The process seems to keep the creature from growing stagnant on the inside. Whatever breathing there is consists simply of absorbing oxygen from the water through the outer surface, and a simultaneous throwing off of waste matter. There is a dull sensibility to light and darkness. There is a mild perception of the flavor of the water in which it floats, but all sensation must be very indefinite. A slight sense of touch tells it when anything comes into contact with it. If this something has motion, the amoeba is apt to clump up and become inactive for a time.

The process of most interest for us at the present moment is its remarkably simple method of multiplication. There is in amoeba no such thing apparent as sex. When

circumstances demand it, and they often do, amoeba proceeds in a most leisurely fashion. It seems to acquire a waist, to grow narrower about the middle. Slowly this portion gets thinner and thinner. After many minutes, sometimes only after hours, its two newly formed portions, each of which has a half of the old nucelus, separate from

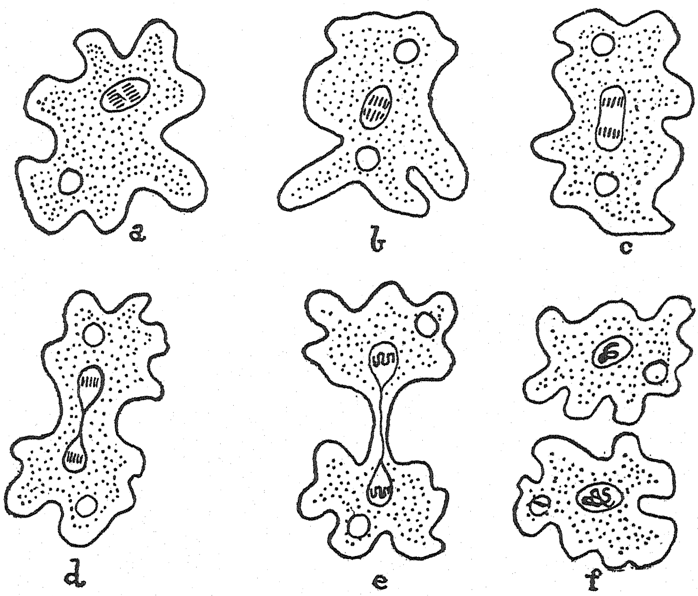


FIG. 25—Amoeba, multiplying by division. *a* to *f* represent six successive stages in the process.

each other. These parted portions afterwards lead an entirely independent existence, and soon grow to the size of the original cell. The two parts are of the same size. It is impossible to think of one of them as the original and the other as separated from it. The original has broken up into two, which are equally old, equally new, and equally

important. In other words, the mother cell, (so it is called, though it is no more mother than father) has become two daughter cells (so called, though they are no more daughter than son). The old cell did not die. The new cells were not born. The big cell became two smaller cells and each of these promptly grew big.

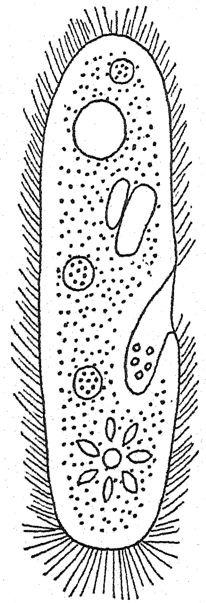


FIG. 26—The slipper animalcule, one of the commonest of the one-celled animals.

It is clear, when we stop to think of it, that here is a very unexpected condition. In the one celled animals (and the same is true of one celled plants) death is always an accident and never a necessity. If death comes it ends the line, because no such one celled animal can give birth to another and then die. If it lives long enough, its life ends not in death but in becoming its own children. If it die, it has no children. If it has children it did not die. And this is true of its parent, and grandparent and so back indefinitely. No such animal has a single dead ancestor. It may have dead brothers or uncles, but it cannot have death in its direct ancestral line. There is no race habit of death. The experience of death does not lie back of any one of these creatures.

Nor does the line grow old and die out. Granted proper conditions, there is perennial freshness to this series of cells. Woodruff for the last dozen years has carried a slipper animalcule, one of the one celled animals,

through more than eight thousand generations, and the line is still quite as vigorous as ever.

The process of multiplication by division sounds strange to a mathematician but is all right to the biologist. This process is a most unpromising one. It holds on finely to the early qualities of the line, but the possibilities of improvement are amazingly small. Long as is the time, the students of radioactivity assure us, during which the earth has been fit for life, and they talk in billions of years, it would seem impossible there could have come so great a variety of life, and that some lines of it should have advanced as high as have the higher mammals. If each new organism was simply half of an old one grown big, as is the case with the one-celled animals, in spite of their age and in spite of the fact that some lines have developed into forms so much higher, it is no wonder that the waters of the world are abundantly populated with the unprogressive members who have been left behind by their more aspiring cousins.

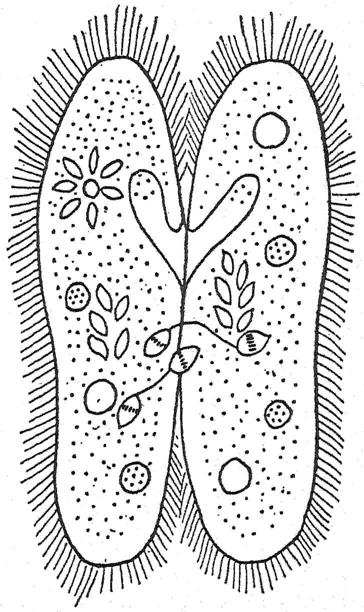


FIG. 27—Two slipper animalcules, trading the determiners of heredity.

Perhaps one of the first steps on the way to more

hopeful processes of multiplication is found in the slipper animalcule, (*Paramecium*). This is one of the commonest organisms in all the world. Almost any water that has stood for a time in the open air will be found to contain it. The largest species are just big enough to be visible to the naked eye, but most of them need low powers of the microscope for their discernment. They have advanced far beyond amoeba, if the latter is really an ancestral condition and not a degeneration as Calkins and some other special students of the group have come to believe. They say amoeba is too stolid to be the forerunner of higher things; it is a creature whose ancestors knew better things and which has slumped.

The slipper animalcule (Fig. 26) which is also a one celled animal, has a definite form, owing to a firmer layer, a sort of skin on the outside. Abundant minute holes in this membrane allow the protoplasm to protrude in multitudes of fine threads (cilia) by waving which he brings about his own locomotion. A dent or pocket on one side serves as a receptacle into which the threads direct the food particles it comes across in its eternal wanderings. It never seems to rest. Every now and then the food at the bottom of the pocket is engulfed into the protoplasm and floats about, a sort of digestive fluid collecting around the food which soon disappears. The undigestible remains are pushed out through a soft spot in the skin a little below the dent.

The great peculiarity of this animal (though some few others share it) is that while it commonly multiplies by division exactly like amoeba and many other cells, every now and then it makes a complicated preparation for the process. Its nucleus is clearly in two parts, a

small nucleus and a large. The small nucleus has in it the hereditary chromosomes. In the course of the preparation, two of these animals lie closely side by side. The small nucleus goes through the regular process of dividing its chromosomes and the portions separate. Instead however of going to opposite ends of the animal, as in ordinary division, one half remains where it is, the other half goes over into the other animal by its side. The latter sends half of its little nucleus over to its companion. Then each animal goes its own way, having lost half of its own nuclear material and gained half of its neighbor's. This process is called conjugation and evidently is the starting point of new, and sometimes of better things. There seems no possible distinction of sex between the two exchanging animals and the process is not a sexual process, though it is glancing that way. The new half nucleus, joined to the old half nucleus starts new combinations of traits that are more promising than if each went on in its own old path.

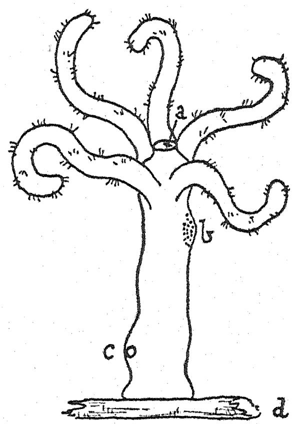


FIG. 28—Hydra with mouth *a*; sperm cells at *b*; an egg at *c*; it is fastened to a plant stem, *d*.

But a fuller and richer form of parenthood is on its way. A new method of combining the qualities of two parents is developing. To see it in action in simple form we must go to another of the lowly animals. Again we

must hunt it in the water; most low life lives in the water. If in some clear pond or the slower reaches of a clean stream we scrape, with a spoon, the stems of plants that stand in the water, such as cat tails or rushes, or the under side of the leaves of water lilies we will be apt to have what we want. The scrapings must be put into a jar, with a few stems and with some plant whose leaves grow under the water and hence will furnish oxygen for the animal. You then nearly fill the jar with water from the same stream. Now bring the jar home and set it in a light but not sunny spot and let the water settle and clear. When all is clean looking, set the jar, without any rapid movement or bumping, where the light is behind it, and examination is easy. If you have been lucky you will find, fastened to the side of the jar or to the plants in the water an animal scarcely an inch long and as thick as a pin (Fig. 28). It consists of a slender thread of yellowish, semi-transparent flesh which ends in five, (sometimes four or six) thinner threads. This lowly cousin of the corals and of the sea anemones is called hydra. Sometimes the color, instead of being buff will be bright green. Touch the animal with your pencil, or tap lightly but sharply on the jar and the threads rapidly shrink and grow thicker, until finally the whole is a hemispherical lump at the spot where the base is attached to the jar or to a plant stem. Its fright however is soon over, and if there be no further jolts, the creature will slowly let itself out again and lie in wait for the small food that comes its way.

The arms are studded with little hair-like projections which are sensitive. If any small animal, such as the slipper animalcule, or a tiny kind of fresh water crab,

runs against one of these "triggers" a cell at its base sends out a slender hypodermic needle and injects the animal with a paralyzing fluid which brings it promptly to rest. At the summit of the body in the center of the bases of the arms is a mound with a hole in its top. This hole can open and close as if by a draw string in the neck of a bag. This is the mouth of the animal and it opens, not into a gullet and stomach as in the higher animals, but into the entire cavity which forms the inside of the sac like body. Here food is digested and absorbed. Any undigested matter is finally ejected from the mouth. This is a many celled animal, as is man, though the cells in the human body number probably a billion times as many as in hydra.

Concerning the lowest living things it is often very difficult to say whether they are plants or animals. They may be very much alike in many respects.

Hydra is an animal. As such it ought to be free to move about, though some animals, like barnacles or oysters do not do so after the first few days. Hydra fastens himself down, the base partly acting like a sucker, partly adhering by a sticky substance which this portion can secrete. If however the spot in which it locates proves to be dangerous, or to be out of the way of food it may move a little distance by a sort of creeping motion, or it may detach itself and float elsewhere, settling in a new location. If this new place proves satisfactory it stays here. If not it tries again until satisfaction comes.

In evidence of its lowly relationship to the plants, we have here one very plantlike method of reproducing itself. A bud appears on the side of the body. This bud slowly elongates, at the same time pushing out arms from

its further extremity. The body cavity of the parent runs out into the new growth and it is thus fed for a time. Then a partition cuts off the young hydra from the parent. At the same time a mouth opens at the far end of the new body and the creature begins to catch things for itself. Now the young hydra tears itself loose from its parent and strikes out on its own career. This process, which the scientist calls multiplication by budding, produces many new hydras. But as in the division of amoeba, we have here in its fullest sense a one parent process. Here again there is multiplication but little or no chance for improvement. The child is just like its parent.

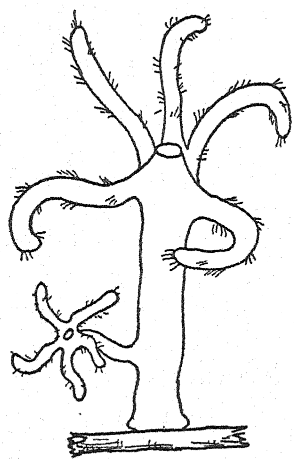


FIG. 29—Hydra multiplying by budding. This is an asexual process.

There is another, and entirely different method by which hydra may reproduce itself. On occasions swellings form on the side of the animal, between the outer and inner of the two layers of cells of which its body is comprised. This swelling may occur near the upper end of the trunk, or close to the bottom. Each of these positions has its own characteristic swelling. If it forms at the upper end (Fig. 28*b*) it will be made of many small cells, if near the bottom, of very few or only one, large cell. The small cells take the shape of a tadpole with a very long and slender tail. The head consists almost entirely of

the nucleus of the cell with its chromosomes carrying heredity. The tail by a rapid vibratile movement can drive the head through the water. This kind of cell is characteristic of the male, and is called a sperm cell.

In the lower swelling the few or often single cells are many times as large as a sperm. Each also has its nucleus of heredity chromosomes, but in addition there is an abundance of protoplasm stored with many drops of fat. This is the characteristic female cell and is known as the egg cell.

In hydra the two kinds may appear on separate animals, on the same one at different times or even on the same hydra at the same time. In this latter case however the sperm cells usually ripen and are discharged into the water before the egg cells of the same individual are ready. By this means is secured the certainty that not both the fertilizing sperm and the egg it fertilizes should come from the same individual. If they did we would have all the elaborate machinery of double parentage and still have only one parent. The process would be complicated and somewhat uncertain, and the result no better than if the parent had budded off its own offspring.

When the sperm is ripe it is discharged freely into the water. Its tail drives it about in any direction. Should it come near the egg cell of another individual, which is ready for fertilization, it is attracted to it. It would seem as if a ripe egg secretes a fluid which gives the water a flavor recognized by the sperm cell and attractive to it. The nucleus of the sperm cell penetrates the egg cell, leaving its tail outside. It approaches, and then fuses with the nucleus of the egg cell which is thus "fertilized." This name was given to the process before the real sig-

nificance of it was realized. The cell now has a nucleus half of whose chromosomes bring into the new life the qualities of the father from whom the sperm cell came, and the other half carry the qualities of the mother in whom the egg was formed.

This fertilized egg goes through a process of cell division, repeated until there are many cells, while the whole mass remains of the size of the original egg. Then it begins to grow. The layers of cells begin to fold and thicken here and there until finally a body is produced, in form like the parent body. This process will be more fully described under the development of the frog, where it can be much more easily observed by the interested student.

Meanwhile the plant side of the living world is also developing its own kind of two parent reproduction. The process has grown more and more elaborate. By the time the ferns were formed it had become fairly complicated and we will look at it there.

Anyone who has observed ferns at all will remember that often on the under side of the leaf are found multitudes of brown spots, round or oblong, and covered or uncovered depending on the species of fern. From these escape minute single cells, known as spores. These are small and light enough to be windborn. If one of these should settle in an appropriate situation the spore sprouts, multiplies its cells and spreads out into a heart shaped mass (Fig. 30), half an inch, or a little less in diameter, with root like hairs running from its underside and attaching it to the soil. Amongst the bases of these hairs, in two localities, as in hydra, swellings are formed. Those nearest the dent of the heart each produce an egg. Those

nearest the tip of the heart produce sperm cells. In the ferns each sperm cell has at least two tails and sometimes quite a number.

At some time when the ground is moist, the sperm cells of one fern plate are discharged into the water. They wriggle about until they happen to come beneath another fern plate whose eggs are ripe. Each egg here lies in a flask with an open neck and the fluid in the neck tastes of

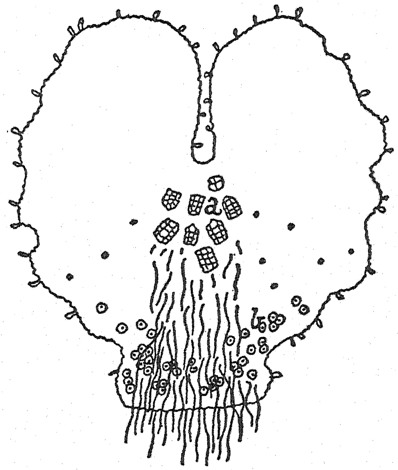


FIG. 30—Under side of a fern plate, showing the egg vessels, *a*; and the sperm spots, *b*.

malic acid (the acid that makes apples sour). Attracted by this flavor the sperm swims down the neck of the flask and hands its nucleus over to the nucleus of the egg. This now grows into a plant with two parents. Without leaving the fern plate it pushes through its top and forms a little fan-shaped leaf. As this grows up into the familiar fern plant the rest of the fern plate at the base dies

and decays away. When the fern is full grown, it again produces spores on the under side of its leaf and the life cycle is complete. In the fern, it is really a double cycle. The fern spore grows into a fern plate, which, because of the fact that it produces the sperms and eggs is called the sexual generation. The fern plant with its spores is an asexual generation. There is thus in all higher plants an alternation of generations, a sexual generation which grows shorter lived as we go up in the scale of plant life, and an asexual, growing more important as we rise in the vegetable kingdom. In the lowest members of the moss family the sexual generation is larger and lasts longer than the asexual. In the ferns the asexual has much the longer life. In the flowering plant the growth of the pollen grain itself and a similar development in the heart of the ovule (to be described later) is all that is left of the sexual generation.

Thus we see that the arrangements for double parentage grow more and more complicated as we rise in the scale, either of animals or of plants. We shall carry the study of the process into the flowering plants to see their ingenious methods of securing the joining of sperm cells with egg cells.

Then we will turn to the animal world and beginning with the fishes run up through the scale, watching the development of fatherhood and especially of motherhood as we rise. Finally we will turn to the multiplication in the human family, quite the highest of all, with a crowning importance won by its being the climax of a long development. This gives it a dignity and a worth proportioned to the time it has been in its creation.

CHAPTER II

THE FLOWER AND ITS STORY

THERE is a complacent philosophy that underlies the thinking of most of us whether we realize it or not. It is the notion that everything in the universe, sun, moon, stars, animals, plants, rocks, everything, has at bottom only one real purpose and that is that you and I shall be comfortable and happy. Chickens lay eggs for us to eat. We know why robins lay eggs, but chickens lay eggs for us to eat. And cows give milk for us to drink. We know why other milk giving animals, dogs, cats, human beings, furnish this excellent food material; but cows give milk for us to drink.

This satisfying theory was never more beautifully implied than in the lines familiar to everyone who knows poetry at all. The stanza begins:

> "Full many a gem of purest ray serene,
> The dark, unfathomed caves of ocean bear."

So far I have no quarrel with the poet. What he says is doubtless both beautiful and true. But my objection begins when he adds the last two lines.

> "Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air."

Of course I do not object to the personification involved in the blush. The flower has nothing for which

it need blush. By that the poet means only that it shows a beautiful color. What I object to is the "unseen" and the "waste its sweetness." What he means is that there is no man or woman about to see the thing, and hence that its beauty is useless.

It is a blessed thing for a wild flower when there is no one there to see it; and admire it; and pluck it; and

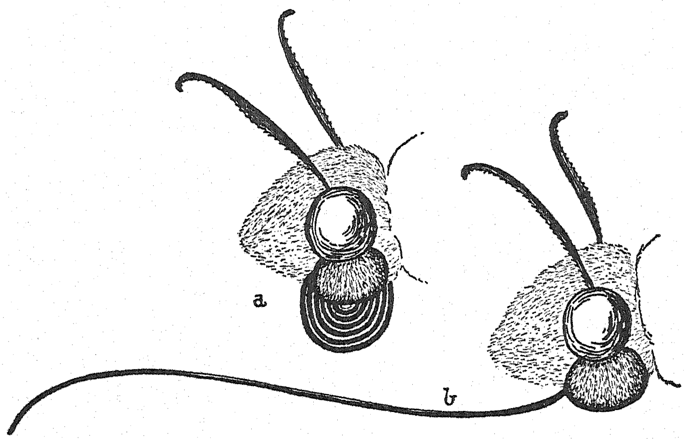


FIG. 31—The head of a butterfly, (the hawk-moth) with its long tongue. *a*—Curled away; *b*—Ready for work

put in his button hole. The flower that has suffered all this is the one that has wasted its sweetness on the desert air, and we are the desert.

Instead of plucking it let us stand aside and see what happens. Along comes a butterfly with fluttering wing and lights upon the flower. He has a long tubular tongue, coiled like a watch spring between his right and left hairy lips. He uncoils this flexible tube and pushes its tip down to the bottom of the flower and sucks up the nectar into

the bulb of his tongue, which is built like a fountain pen filler. Then he goes his way. Later a humming bird appears. He may go to another flower, or if a half hour has elapsed this one will again be stored with nectar. He need not light, but balancing on quivering wing, he probes the flower with his hollow tongue and goes his way. To still another flower, or to the same after another interval, comes a bumble bee on shivering wing. He too lights on the flower. His long tongue, laid against the under side of his body, reaches nearly to his waist. This he bends forward, and inserts into the flower, drawing the nectar up into his crop. Then he goes his way. When we pluck the flower we end its work. When these visitors come, each gets his pay in nectar for a most valuable service he renders the flower. Doubtless he knows not he has done anything for the flower or that the nectar is a reward. Unwittingly these animals have taken a part in one of the most important life processes in the plant's whole history, if not the most important. Now the flower can go on with its development and produce its seed. It is with the express purpose of securing these visitors that the flower has produced its highly colored petals, the parts which give it beauty, without which we scarcely think of it as a flower. Who but a botanist thinks of the tassel, and the young ear of corn as flowers? They are quite as truly flowers as are the blossoms of the lilies, or of the roses.

Let us take a familiar plant and look it over and see whether we can examine into its complicated machinery, watch it go through its elaborate process, see it come out with its valuable result, and hence understand the meaning of a flower. Thus we may fathom, I say it rever-

ently, the purpose of God when he made a flower. We cannot use a rose for this purpose unless there happens to be at hand our Northern wild rose, or a Cherokee rose, or a rugosa rose. A rose as God made it had five petals. Now and then one gets all bewildered and turns some of its own stamens into petals and becomes double. In a state of nature such a monstrosity would with difficulty maintain itself against the competition of the much more fertilizable five petaled rose. But the monstrosity of nature pleased man's eye and he propagated it by buds or slips or grafting. Such a rose will not serve our present purpose. Nor will a dandelion. It is as God left it, but it is not a flower. It is a bouquet of two or three hundred flowers and the untrained person could not well see the process even with a magnifying glass.

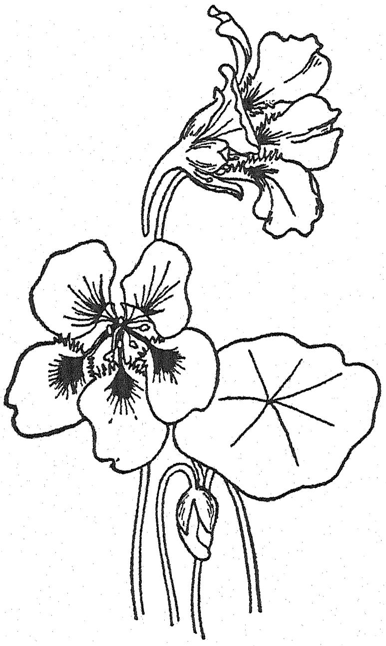


FIG. 32—The nasturtium with its rounded leaves, concealed bud, and flaunted flowers.

I suppose no cultivated flower is more abundant or available through a longer season than the nasturtium, and we will choose it for our purpose.

Looking then at the familiar plant the first point that strikes us is the unusual shape of the leaf. Most leaves are more or less oblong. The stem hits them at one end and runs through the middle of the leaf for its entire length. But the nasturtium leaf is round and the stem hits it in the middle of the under side. It has just the shape of an umbrella; indeed it is an umbrella. If you pour water on your nasturtium patch it runs off the leaves. If any remains it stands up in round drops, not wetting the leaf, which is waxed for just this purpose. Most plants seek water. Why should the nasturtium throw water away? If we are to understand this we must, in imagination, trace it back to its native home. Our cultivated plants are the wild plants of other regions, often much modified by our fostering care. Though we have a rhododendron on our mountains, for our lawns we are not content to use this but go to the Himalayas of India and bring from there the stocky, big flowered varieties we grow. The plains of eastern Europe and western Asia have given us our tulips and hyacinths. Japan has made our spring bright with the yellow Forsythia and the scarlet Japonica, our walls green with the absurdly named Boston Ivy and our fall gorgeous with Chrysanthemums.

For the nasturtium we must go to the eastern slopes of the Andes in the Peruvian neighborhood. The trade winds sweeping across the Atlantic, and passing over the whole width of South America without encountering any great elevation, here are suddenly forced up to pass these mighty ranges. The pressure off, the air expands, cools, and drops its abundant moisture. So terrific is the downfall that three of the most magnificent rivers of the globe head here, the Orinoco, the Amazon, and La Plata. Here,

where water is a drug on the market, the nasturtium has learned to discard the substance most plants seek so eagerly.

Beneath the leaves, shrinking from observation on shortened stems and blending with the background by their green colors are the buds. Their time has not yet come, so they do everything they can to escape notice while their machinery is getting into order on the inside of their green cover.

There comes a day when the preparation is complete, and the flower is fully prepared for this, the crown of its life work. Now the stem lengthens, the cover of the bud splits open and the gorgeous corolla spreads itself vauntingly. All concealment is over and the blossom's chief purpose is to secure notice. Unfortunately it too often secures our notice and we pick it and that ends its natural work. But enough escape our attention to meet the eye of the bee, or the butterfly for whom they are intended and these accept the invitation.

Our cultivated nasturtiums are of every shade between a cream color and a dark reddish brown. But if we let them run wild, and seed themselves, and spring up next year from those seeds our abundant varieties are soon lost and we have flowers that are lemon yellow with orange colored patches and stripes. They have reverted to their natural Peruvian type.

We will leave the bright colored corolla for the present and come back to it after we have learned to know the much more important parts (the botanist calls them the essential organs) which lie farther in at the heart of the flower.

First come the stamens (Figs. 33-*a* and *b*). These

have long slender stems that curve first down and then up, and each terminates in a two parted head. In this head lies the yellow, dustlike pollen.

In most flowers the numbers of stamens is quite definite. The lily has six, the iris three, "butter-and-eggs" four, (and about a tenth of another). Evidently we have a story here. The nasturtium was once a geranium. When it started to deviate from its geranium plan and to get its long spur, or sack at the back, which contains the nectar, and which the geraniums do not have, it had to make changes in other parts to fit them into the new plan. Several of the stamens barred the way into the spur. So the plant learned to bend all of them down out of the way, and discarded some entirely. Now it was in doubt how many to discard, and it is experimenting. Sometimes but one is lost, much more frequently two, occasionally three and very rarely four. It seems to by settling its mind on two. So after a while (say ten

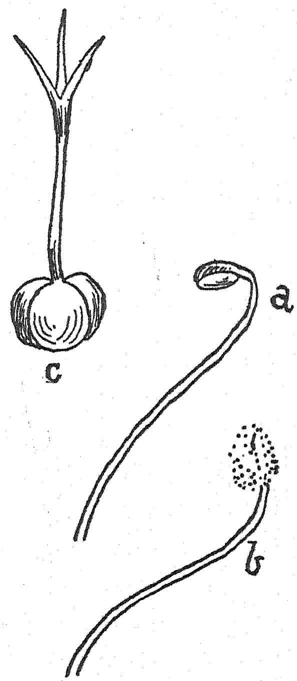


FIG. 33—The essential organs of the flower; *a*—The stamen, containing the sperm cells; *b*—The same discharging the pollen grains; *c*—The pistil, containing in its base the egg cells, and with top split, ready to receive the pollen.

thousand years) all nasturiums but an occasional maverick will have eight stamens.

Each stamen, in any flower, is made up of a stem, usually long and slender, which holds the head (anther) in such a position, varying much in different flowers, as will bring it where insect visitors will brush against it, for a reason which will be made clear later. This head contains the pollen grains. Each of these grains contains two cells, the main one of which is the actual sperm cell. The nucleus of this cell contains the chromosomes made up of the determiners, which carry into the new seed and potentially the new life, which this grain may help to form, the qualities of the plant from which the pollen comes. This plant will be the father of the new seed.

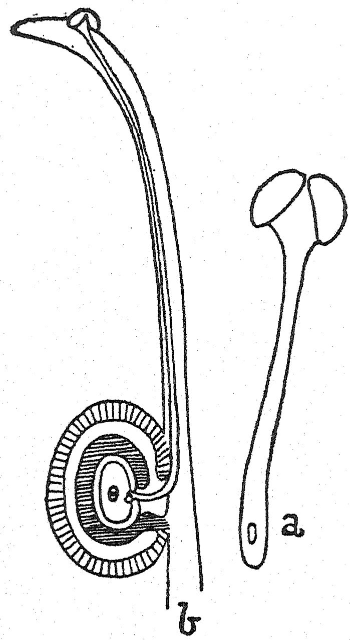


FIG. 34—A pollen grain fertilizing the egg cell. *a*—The sprouting pollen tube much magnified; *b*—A section of one-third of the pistil with the pollen tube less magnified approaching the egg cell in the ovule.

The structure of the pollen grain will be best understood by those who have no microscope with which to study it, if we compare it with the plan of a hen's egg. We must guard however against thinking it an egg. The

pollen grain which may be one hundredth of an inch in diameter has a hard shell on the outside. Beneath this is a leathery shell, as in the hen's egg. Within these is a glairy substance, the protoplasm, looking very like the uncooked white of an egg. At the center, smaller in proportion than the yolk and not colored, is the nucleus of the cell.

To study the action of pollen we take a drop or two of a five percent solution of sugar in water placed on a microscope slide. Into this we first stir with a needle (sterilized by heating it in a flame and allowing it to cool) some of the pollen of our nasturtium. On a plate lay a blotter or two saturated with water. On this lay the microscope slide, with its sugar water and pollen, and cover all with a finger bowl. This will keep the sugar water from evaporating. Set this in a place slightly warmer than comfortable room temperature. In a day, or two at the outside, examination will show an interesting state of affairs. The pollen grain will absorb enough of the sugar water to make it burst its hard shell and stretch the leathery shell until it protrudes from the crack. Then this finger-like projection will grow until it has gotten many times as long as the grain from which it grows (Fig. 34-*a*). Meanwhile the nucleus will slide down this tube to its farthest end. We will leave the consideration of the sprouted pollen grain with its sperm cell and father nucleus for a while and come back to it a little later.

Within the circle made by the bases of the stems of the stamens in the nasturtium lies the central organ, the pistil (Fig. 33-c). This is the other of the essential organs of the flower.

At the base of this pistil lies the so-called ovary, made up in the nasturtium of three rounded green bodies, placed against each other. From the center of the group rises the upright stem (style) which splits into three sections (stigmas), when the pistil is ready for its work. Inside each of the sections of the ovary lies an ovule, which if its egg cell be properly fertilized will become a seed. In its very center lies the single egg cell. This has a nucleus which furnishes to the new life, if seed be formed, the determiners which settle that in half its qualities the plant which grows up from this seed, shall resemble the plant on which the seed is formed, which is the mother plant.

Now what is this fertilizing process which makes the ovule grow up into a seed, which, planted in appropriate soil, will grow up into a new plant?

It will be seen that in the nasturtium as in most flowers we have both stamens and pistils. That is, the plant is of two sexes. Combining the Greek name Hermes of the god Mercury and Aphrodite of the goddess Venus we have the word hermaphrodite, describing an individual which is of both sexes. This state of affairs is very common, though not universal, in flowering plants, as it is very uncommon in higher animals though not infrequent in lower. For instance the earthworm is a hermaphrodite animal and the willow amongst plants is single sexed.

But while the nasturtium has both sexes in the same flower, and hence can serve as either parent, it is very rarely father and mother to the same seed. To prevent this double service usually the stamens ripen first and discharge the pollen. Only after this process is over and

the pollen has been carried away, does the pistil spread its stigmas to receive the pollen from another plant.

By some means, the methods to be discussed a little later, a ripe pollen grain must be placed upon the split end of a pistil, which is ready to receive it. When so ready, the stigma has sweated out a sugary secretion in which the pollen can sprout and send out its pollen tube, this grows down through the tissues of the style (Fig. 34-b). When it reaches the ovary the tip of the tube finds a small opening through the coat of the ovule and penetrates its tissues until it reaches the egg cell. The sperm nucleus has meanwhile moved down to the end of the tube. It now pushes its way out, enters the egg cell and fuses with its nucleus. We now have a fertilized egg cell, which will stimulate all the tissues around it to grow into a seed. This seed, appropriately planted, will spring into a new plant which owes half its characters to its mother, on which the ovule grew, and the other half to its father, from which the pollen came. Science has learned to recognize the extreme significance of this process, and it will be the subject of our next chapter.

When the earliest organisms developed into higher forms they gradually separated into two great groups, the animals and the plants. Slowly it became the established characteristic of the animals that they move about freely. Not all do. Corals for example and oysters, after the first few days of life, become stationary. Meanwhile plants, as they grew into more highly specialized forms became fixed to one spot. This is due to their different methods of feeding. Plants can put their roots into the ground, soaking up water and mineral matter, and their leaves into the air, taking in carbon dioxide.

These substances meet in the leaf. This organ can spread out, catch the sun power, put it into the ingredients mentioned and make sugar which is the fundamental food of the world. Out of sugar the plant makes all its other foods, and from them builds everything it has. The animals eat the foods the plant has made, or eat other animals which have eaten the plants. So the fundamental food factory is the green leaf. This must be held out into the sun light to get its power. Hence the shape of a plant, and also its fixed position. It gets its name from this fact, it is planted—that is (planatus) its wanderings are over.

But if it is fixed like this, and since nature wants her children to have two parents, how is the parent cell of the male to reach the parent cell of the female? Somehow the pollen grain with its sperm cell on one plant must get to the pistil with its egg cell, on another plant.

Nature uses several methods by any of which this may be accomplished. In corn, the pollen grows on the tassel. Each undeveloped grain on the young ear is the ovary of a pistil, of which a thread of the silk is the style. When that particular organ is ready for its work its thread of silk lengthens, sticks out of the end of the husk, grows moist, and catches a pollen grain brought to it by the wind from a neighboring corn stalk. This method is exceedingly wasteful, and the number of pollen grains lost must be enormous compared with those that strike the tip of a silk.

There are on a big ear of corn perhaps twenty rows of about fifty grains each, say a thousand grains. I have no doubt it is quite safe to say the tassel produces a thousand million grains of pollen. To prevent the tassel dropping

pollen on its own silk, the former is only dislodged when the wind shakes the stalk. The pollen is so light that the wind which made the plant quiver bears the pollen away. Furthermore, the second leaf above the ear springs from the stem in such a position as to lie directly up from the tip of the ear. It thus shields the silks from pollen that falls vertically, but leaves it quite open to that which blows in from the side.

The wind is so wasteful of pollen that nature has devised a far higher and more elaborate method of directing its transportation. It is this that has given the world its highly colored, attractive flowers, with their alluring odors and rewarding nectar.

Now let us return to our nasturtium and knit up the odd ends that we have left hanging loose.

While the flower is still unprepared to do its work, and is getting ready, it has the form of a bud. A few green leaves, whose shape is much altered for the purpose, form a tight covering that protects the tender growing inner parts from any inclemency of the weather and the as yet unwelcome entrance of intruding insects. During this time the bud stem remains short, and the bud tries to hide itself by keeping the color of the leaves under which it crouches. After a time the inner organs are all formed and the pollen and egg cells have all gone through their multiplying and assorting divisions. Now all is ready for the mating of the flowers, which requires the intermediation of a kindly friend.

The stem lengthens, pushing the bud up into the open space above the leaves. The green case splits into five sections and lets out the as yet crumpled yellow corolla which rapidly unfolds and expands, flaunting itself into

the full view of every passing creature with eyes sensitive to its color (Fig. 32). Unfortunately for the flower, we see it then and imagine it is calling to us. We are likely to come and pick it. If we do so we end its life process. But if we will desist, its real friends will obey the call. The roving bumble bee, seeing the sign obeys and approaches. The general yellow effect of a group of flowers breaks up into the clearer appeal of a single flower as the insect comes closer. Arriving at the flower, a new instruction meets his eye. Each of the three lower petals has an orange colored bloch on it. Which one of these shall stand most invitingly depends on the position of the flower. Usually it is the lower middle one. The orange spot tells the bee, in unmistakable language exactly where he is to light. Just behind the spot is a line of fringe which serves as a fence to keep him from coming too close. Looking over the fringe at the upper petals, the bee sees orange lines on them, directing him to the opening into which he is to thrust his long tongue. This opening leads back into the horn or spur at the back of the flower. Inserting his tubular tongue the bee draws up

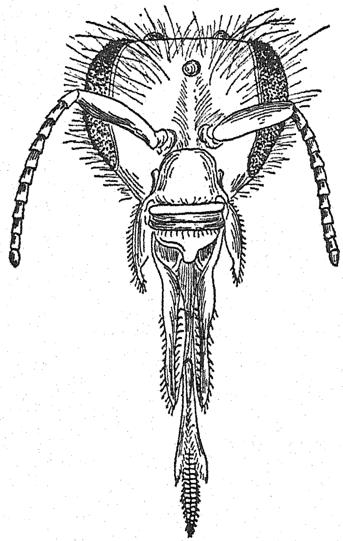


FIG. 35—The furry head of a honey bee, with its long tongue.

into its crop the little drop of nectar which has been secreted there, and which was, to the bee himself, the object of his visit. But as he leans over the fence and probes the spur, he is quite unconscious of the fact that the stamens lie just beneath his head. He unwittingly gets his abundant and bushy whiskers thoroughly covered with nasturtium pollen.

There is not nearly enough nectar to fill his crop. Indeed I have seen him visit twenty-five nasturtiums before his bulb was filled, and he had to go back and empty the nectar into a honey jar in his home. Here several of his companions are fanning the jars with their wings and evaporating down the nectar. When this is thick enough, and perhaps also somewhat altered by a ferment put in from the crop of the bee, a sister puts the tip of her sting into the jar and adds a small drop of the stinging fluid, formic acid, a preservative, and now it is honey—and is very good.

If this had been a honey bee we could not have said he to all this. It would certainly be a female for amongst the honey bees the males are drones and are perfectly useless except to fertilize the queen. But amongst the bumble bees the males work, though probably not as industriously as the females. But they cannot put in the formic acid. The sting is an altered egg placer and as such is found only in the female. That is why the males, which have a white square in the face and are known to the country boy as white heads, cannot sting.

I have said the bee can go to many flowers before his crop is full. Fortunately for the flower, having begun on nasturtium he sticks during that entire trip to flowers of this sort. The yellow of the dandelion or the St.

John's Wort will not lure him away. He is nasturtium set for this trip and to these flowers he sticks. Mr. Huxley says the bee has long since learned what man is slow to learn, that it makes him sick to mix his drinks. In any event he commonly sticks to one sort of flower for an entire trip. Probing the first he may get pollen on the hairs that cover his body. Reaching the next nasturtium he may get more pollen. The third perhaps has already shed its pollen and other bees have carried it away. But here the pistil is ripe. Its end has separated into the three stigmas and they are moist with a sugary secretion. This moist tip of the pistil pushes amongst the pollen laden hairs of the bee, and some grains at least adhere to the sticky surface. These sprout there, their tubes push down the pistil. One of them finds the opening into the ovule (probably attracted by a slight secretion of malic acid). The nucleus of the sperm cell finds its way to join the nucleus of the egg cell, and this act of the drama of life is complete.

The varied forms of flowers are chiefly designed to adapt them to insect fertilization. The orchids especially have taken on very fantastic forms with this function in view. In the lady-slipper orchids (*Cypripedium*) (Fig. 36) the bee enters the opening in the upper surface of the slipper. Guided by colored lines on the floor of the flower, he passes first the pistil and deposits on it any pollen mass he is carrying. He then emerges through a small opening near the stem, picking up another pollen mass as he goes out. The structure of the flower is such that he cannot reverse this course. If he did so he would carry the pollen of this flower to its own pistil, and thus defeat the aim of the flower to secure cross fertilization.

For this attraction of the bee the flower put out its beautiful corolla. For this it shed forth its pleasing odor. To secure this it secreted its rewarding nectar. The bee got what it wanted; food. The flower got what it wanted;

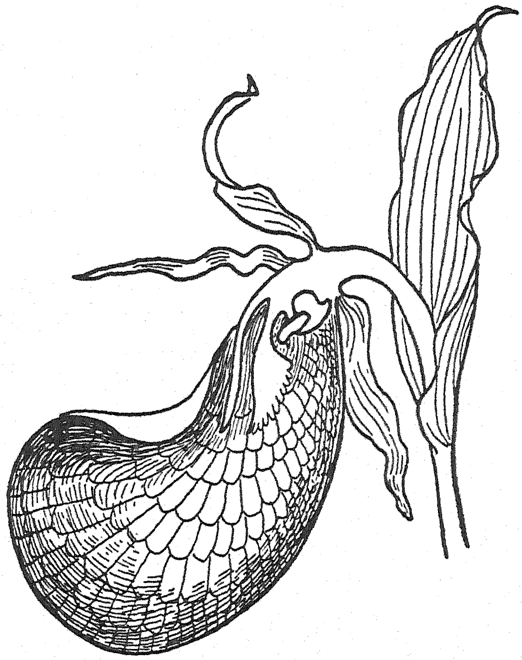


FIG. 36—A section through a lady-slipper orchid

fertilization. Nature got what she wanted; a new seed, with a new life, having a new combination of the qualities of two parents. This better flower will be a new step up in that "one increasing purpose" that "through the ages" runs.

Could the flower ever have thought this all out for itself? Could even the bee have accomplished this?

Though working through countless years, could chance happenings have blindly sifted themselves out to such good purpose? Is not such coadaptation, so wonderfully helpful to two such different creatures, the necessary result of something like that which in ourselves we call intelligence?

It may be, I think it is, child-like (though not childish) to think of God as planning it, as we would plan a machine, and then making the parts and putting them together. God is so infinitely greater than we, that to use terms that describe us and our work in describing Him and His work is utterly inadequate; but it is the only way we can have. Somehow the infinite power, acting with infinite resource, having infinite matter through which to operate and infinite time to accomplish its unendingly increasing results is at work back of all this activity. I like the happy phrase "creation by evolution." It is not a Godless phrase. It does not imagine a Godless process. It is our impotent way of reaching one step farther towards a glimmer of an understanding of the workings of an Infinite Power whom we lovingly name God.

CHAPTER III

WHY WE HAVE TWO PARENTS

THE last two chapters bring us face to face with one of the most important of all the problems of biology. Why is it that God has given to most of His higher children in the plant world and to all of His higher children in the animal world two parents instead of one?

Out in the garden are rows of strawberry plants. On them, in season, hang luscious red fruits. Each berry has on its red surface little yellow points in abundance. Everyone of these points contains one seed. Carefully removed and planted, each might grow into a strawberry plant. This plant would have two parents. Its mother is the plant on which the fruit grew, its father is the plant from which a bee got the particular pollen grain that, transferred to the center of the mother plant, fertilized the one particular pistil which ripened into the point (achene) that held this seed.

Meanwhile, as the season advances, slender stems (runners) stretch out from this plant and after growing to a length of eight or ten inches they root at the tip. A circle of leaves springs from this rooted end. This grows up into a new strawberry plant, the runner later drying up. This plant has only one parent, the plant from which it sprung. When we want to start a new berry patch we do not buy seeds and plant them. Not a seed catalogue

in the market contains the advertisement of seeds of strawberries or raspberries or blackberries. We always buy "plants" of these. No peach stones are sold for planting in our orchards. You buy small trees that have been "budded"; that is, all of it above the ground is simply the outgrowth of a bud cut from another plant and put into a vigorous rooted seedling grown from a bitter wild peach. When the bud had sprouted, the seedling stem was cut off just above the bud, and out of the bud has grown a single parented tree. Why all this trouble? Why not just plant a peach stone?

Man's practice is very clear and definite. When he is anxious to get just the sort of plant he had before he uses single parented offspring. If he plants the little strawberry plant at the end of a runner he knows he will get berries just like those on the plant from which the runner started out, and of course this is just what he wants. He plants that particular shoot because he wants the sort of berry borne by the plant it sprang from. No one would want to plant strawberries in his garden if each plant might give a berry of a different shape, maturing at a separate time and with a varying flavor. This the seedsman may try. He will grow seedlings in which he has taken pollen from one plant, with one quality he wants, say size, though its flavor is poor. He puts this upon a pistil of a plant with fine flavor though its fruit is too small to be valuable. He lets the fruit ripen fully and soften. He washes out the little achenes and dries them. He plants them in a carefully selected soil. Then he lets them grow up. The fruits of this generation will vary greatly. Out of several hundred plants, two or three will have fruits as large as the father plant, which

at the same time have a flavor as fine as the mother. One of these plants perhaps matures its fruit a little earlier than either parent and hence comes in before the price of strawberries has dropped. Here is a plant better than either parent. It is large fruited, fine flavored and early bearing.

He takes this plant and puts it in the richest soil and guards carefully every runner, seeing that it gets a good spot in which to grow. Next season he puts out one little plot entirely in this plant and its separated runners. In a few seasons he has enough of his new plant to put on the market. If his name is Patterson he may market it, at a much higher price than ordinary as a new variety which he may call Patterson's Seedling.

The same is true of the peaches. If I want an alberta peach I buy a tree grown up from a bud cut off of an alberta peach tree. If I plant a peach stone from the same tree, I might get a true fruit or I might get any sort of a mixture of this strain with something else, and the result might be good, bad, or indifferent. It may have been pollinated from any sort of peach in the neighborhood.

So with our potatoes. While the farmer may plant what he calls seed potatoes, they are not seed at all. They are pieces of the underground stem of a previous potato plant which was its only parent and it will be exactly like its sole author. It is not grown from seed. Our potatoes now rarely produce seed though they blossom abundantly. An occasional plant gets a bluish-green fruit where the blossoms were. This has seed in it, but nobody but a professional hunter for new varieties even plants them.

In the animal world there are no single parented examples that are as high in their group as strawberries or potatoes are in the plant kingdom.

Perhaps the highest example of an animal with one parent is the male honey bee. In the hive there are produced three kinds of bees. An egg, fertilized by the sperm cell from a male bee, fed after hatching, with very rich food and given plenty of room for development comes out a queen. She does all the egg laying for the next generation. A fertilized egg, less richly fed and with a much smaller cell in which to develop grows into a worker of which there are thousands in one hive. These gather the nectar, build the cells, ripen the honey and feed the children. An unfertilized egg grows up into a male whose only function is to fertilize a queen. Inasmuch as few queens are born, and there are hundreds of males to each hive, it is evident that most males fail of the accomplishment of their life's mission. Why the male honey bees have no father, has not yet been divined by the scientist, but the fact is clearly proved.

In the spring the young tender shoots of the roses get covered with little green plant lice. Connected with at least some species of these there is a most strange circumstance. The first brood of a season has in it males and females, which mate with each other. The life is short and there are a number of broods to a season. The second and third, perhaps the fourth generation will consist only of females and their offspring will have had no father. As the end of the season approaches again there is one generation with males and females who mate.

We have seen that the young hydra may bud off of its mother, the only parent, or it may be produced from the

united egg and sperm of two individual parents. We have seen also that the lowest animals all multiply by division. Thus each has but a single parent. This at least makes it perfectly clear that two parents are not necessary to reproduction however thoroughly that method prevails in the higher animals, where now it is the only possible form. What is the gain?

It evidently is neither speed nor certainty of reproduction. The speediest reproducers in the world are probably the bacteria. Under appropriate conditions of food warmth and moisture one bacterium may grow to thousands within twenty-four hours. No sexual process can equal this. Where is the gain?

A close friend of mine has a beautiful female collie dog, of fine lineage. She took her many miles to mate with a famous male of equally high pedigree but in a different line. A half a dozen dogs in the litter were all collies of course. They were all fine collies, but not all equally fine. Two of them had exactly the line from back of head to tip of nose that a good collie should possess. The others bent up or down a little from the line. Some of them held their ears finely but the tips did not both turn down. Some of them were light on their feet; the others much heavier. Some had fine ruffs about the neck, others were not so well provided.

One out of the litter had the fine head line, the erect ears turned at the tip, the full ruff, the light feet. Here was a dog that combined in himself the best points of two parents. He was the worthy sire of a new strain of high bred, fine pointed dogs. The judges acclaimed him. So are fine collies obtained, and they are held at prices none but a collie lover can comprehend.

I have a friend whose grandfather was a business man of prominence sixty years ago. This elder man was apparently in fine health and full activity, when as a boy I first knew him. Suddenly one day, his secretary came into his room and found the man at his desk with his head bowed on his hands—dead. His heart had failed him. Its valves were defective.

Years later his son, my friend's father, about to leave the house, found he had forgotten his watch which was on the bureau in his bedroom. He hurried upstairs, reached the top out of breath, sat down for a minute on the couch, turned over on his side and was dead. He had inherited determiners that had the same lineage exactly as those that settled his father's bad heart. If his children are to inherit from one parent only and that the father, it will be difficult for them to escape the same fate. It would be "in the blood."

My friend's wife comes from a line of entirely different history. Sudden death is with them unknown. Their hearts are of splendid construction and their arteries strong and elastic late in life. But they yield to pulmonary tuberculosis. One by one her people have passed out by the same door. Later years have brought better understanding of the situation and care has saved them longer—but it is only care that has done it. Carelessness would bring on the same old difficulty. Tuberculosis is not hereditary, but it seems clear that an inability to fight tuberculosis effectually may be transmitted. Should the children derive their qualities from their mother alone, they have little doubt as to their probable fate in later life. Here are two sides, each on the whole very good, yet

each side has one serious defect. Neither alone could produce a great line.

But nature brings together these two strains. The children inherit partly from each. Nature's hope is that somehow into one child will come the good of both sides and the bad of neither. Such a child these people have. Their son has evidently inherited from his father's side their vigorous lung and from his mother's side their well built heart. Such a child is nature's darling.

Of course the other possibility may turn up; is perhaps quite as likely to turn up. In my friend's case it has not happened but it might have. His daughter is vigorous, like the son. But let us suppose the reverse had happened, and she had inherited from her father's side a weak heart and from the mother's the weak lung.

Now we have the best combination possible and the worst. All the good came to one and all the bad to the other. At first sight it would seem nature is no better off now than she was before. But she is. The one child grows up strong and hearty, the starting point of a line better than either of his parents. The other child, dowered as she is with weak heart and weak lungs, can scarcely survive the hard first year of life. Should she pass this, the third year with its dentition is quite a crisis, followed by a similar difficulty at seven with the second dentition. With thirteen and the incoming of young womanhood comes a very difficult time for a weakling. A judicious mother, advised by a skillful physician, carries her through this. All seems to go well until about twenty when the weak lung succumbs. She has lived long enough to be a joy to herself and those about her, but when she might naturally transmit to new life her serious

combination of defects she passes off the stage, leaving to her better dowered brother the perpetuation of that line. God is forever giving His higher children two parents. It is thus they came to be higher children. And thus they will become still higher. So nature is forever getting better nasturtiums and better strawberries and better collies and better folks.

Now and then it happens that a son, the select product of two fine lines marries a girl, the equally fine product of two other distinct lines. Rarely it happens that in one of their children will be blended all that is fine in the four lines, and little that is weak. Such men are the starting point for higher things, both in their blood and in their example. So comes a Socrates, a Paul, a Dante, a Shakespeare, a Lincoln, a Gladstone.

Now what is the machinery by which such a result is brought about? Let us trace the history of an egg cell say in the hen. The original egg divides, and divides again, and again. By the time we reach perhaps the sixteen or the thirty-two celled stage, one of these cells is set apart to multiply eventually into all the eggs this chicken will ever lay, and many that will never be discharged. The other cells grow up to make the body of the hen. They are the body plasm—the one with its descendants is the germ plasm. The germ plasm finds itself finally enshrined in an ovary built up by the body plasm. These germ cells multiply until at last each becomes an egg.

Just before this has reached its final stage there is a peculiar process of ripening (maturation) during which occurs a unique activity known as a reducing division. In every other division, as in the case of cells generally,

one-half of each chromosome goes into each cell and the two cells are thus alike. But the next to the last division differs from the others.

The two determiners relating to the same function, one coming from the father and one from the mother, pair. When cell division comes, instead of each determiner splitting, none split, but one of each pair goes each way. The resulting egg cell has now only half as many chromosomes as the cell it came from. The interesting thing about the process is that there is no telling which one of any pair will be retained and which discarded. The ripening of each egg is like the shuffling of a pack of cards and the discarding of half the pack. Each egg is a different shuffle, and each egg has only half enough chromosomes.

The history of a sperm cell is almost exactly similar. Finally each sperm has only half the number of chromosomes contained by the body cells. When a sperm meets an egg cell and fertilizes it, the number of chromosomes is again full; but each pair is a different shuffle and discarding of the qualities of the two parents. This is the heart of the double parentage problem. It is not simply reproduction. That was well provided for by the early and lowly process of multiplication by division. The new process gives abundant variations. The successful variations survive, the unfortunate combinations drop in the struggle for existence. So God is ever raising his great creation to higher and nobler levels.

Recent years have given us a new insight into a question which has puzzled man for ages and to which different men have given very different answers. What determines the sex of a human child? Can man do anything to make the birth of one sex possible rather than

of the other? Can the parents determine the sex of their children?

Many answers have been given; most of them without possible foundation.

One says that abundant feeding on the part of the mother favors the formation of girls. Another says alternate eggs are discharged from right and left ovaries, and that one side produces males and the other females—which is demonstrably false. Birds have permanently lost one ovary. Some say that if the egg is fertilized soon after its discharge from the ovary, it will be male, but if it be fertilized late in the cycle it will be a female. This seems equally without foundation.

Present day science's answer to this is the following. In the cells of the human female there are forty eight chromosomes. This is true both in the case of body cells and of germ cells. When the latter come to their ripening, final divisions, twenty four chromosomes are always found in the egg; the other twenty four being thrown away, into two little spheres. These were called polar bodies, when they were thought significant, but are now known to be only atrophied eggs. One of the twenty four chromosomes in the matured egg is smaller and differently shaped from the rest and is known as the x chromosome.

Strange to say the male body cells and the male germ cells have only forty seven chromosomes. When the germ cells ripen into sperm cells and the reducing division comes into play twenty four chromosomes go into one sperm cell and twenty three into another. In the latter case the x chromosome is lacking.

Human egg cells, before fertilization are all of one

kind and have in each egg cell twenty four chromosomes. But there are in the same individual two kinds of sperm cells, in equal abundance. One of these kinds has twenty four chromosomes including the x, and the other has twenty three, lacking the x.

If an egg, always containing twenty four chromosomes and including an x, meets a sperm cell which also has twenty four, including an x, the fertilized egg cell has forty eight, including two x's and grows up into a female. If on the other hand the egg is fertilized by a sperm that has only twenty three, lacking the x chromosome, the resulting fertilized egg cell has but forty seven chromosomes including only one x. This will grow up into a male. It seems as uncertain exactly as heads and tails in the flip of a coin. At present there is no information at the disposal of man that will in any way influence the sex of unborn children. At least that is the practically uniform belief of recently educated biologists and of recently trained obstetricians.

CHAPTER IV

FISH AND FROGS AS PARENTS

WE HAVE watched the change from one parent reproduction, which the scientist calls the asexual process, to the two parent or sexual plan. We have seen what a marvelous process the latter is, giving its steady uplift to creation. In all the lower animals there is also another aspect of the matter. The rate of reproduction is enormous, but the destruction is equally enormous. If any one animal were to reproduce at its normal rate, and none of the offspring die, the world would be full of that one in a comparatively short time. Inevitably the large proportion of them must die. There seems to be about so much room needed for one of them, and the numbers each year are measurably the same. If something happens to their enemies the animals may easily become a pest. Brought to Australia without their enemies, rabbits became so abundant and destructive that whole counties surrounded themselves with rabbit proof fences and then had an official killing of all the rabbits within the fence. When the ranchers of Wyoming killed off the wolves the jack rabbits became so abundant that neighborhood drives were arranged. The rabbits were chased into an enclosure, and killed by the tens of thousands. Their carcasses were sent to the poor of the big coast cities.

In Pennsylvania every now and then the game wardens arrange for the killing of a number of does in one season. Does are ordinarily protected entirely, but in some counties deer become so abundant as to be a menace to the crops.

Exactly the same balance is preserved in nature. If the enemies of any animal are scarce, the animal multiplies abundantly. But during the next season the food for the enemy is so plentiful that the enemy thrives and multiplies and the first animal is once more reduced to its normal number for that environment.

In other words, commonly speaking any animal reproduces in the long run and on the average just one in his lifetime that lives and prospers enough to take the place of the dying parent and keep the population even.

In America while land was abundant, immigration was encouraged and this country was the refuge of the world. Then as the cultivable ground was well taken and still they came, over crowding, at least in a sense, brought down the scale of living. The barriers against immigration were put up until again the numbers grew smaller compared with the demand and now the workman rides to work in his auto and much fewer people than used to, carry the "full dinner pail," because they buy a hot lunch.

After the development of the two parent plan nature began another line of improvement. Why kill off so many? Why produce so many? Why not fewer and better animals, that can help themselves more efficiently. So sponges get prickles in them that make them bad eating. Worms get a bitter flavor and live in greater safety.

In two great lines of the animal kingdom the insects

and the backboned animals a still higher device arises, but only in the upper sections of each line.

Most insects make no provision for their young beyond placing the egg on or in or if that is impossible, near the food the young must eat. Grasshoppers lay their eggs amongst the roots of the grass and then die. The amount of spring heat necessary to hatch these eggs also sprouts young grass in time for them to eat it. The codlin moth lays its egg in the blossom of the apple. When it hatches into a "worm" (larva) it lives on the heart of the apple. When the apple falls, the larva emerges, hides over winter and is a moth in spring, exactly at apple blossom time.

But few kinds of insects live to care for their own young. With the exception of the so-called "white ants" which are not ants at all, all these social insects are bees, wasps or ants. These insects live in communities so unlike our own, and these animals are so unlike us in the whole of their psychology, that we have little to learn from them, for little they do would be possible in our lives. How small the possibility of our learning from the bee will be seen when we realize that only one in five thousand females amongst the hive bees is married and that one has thousands of children. All the rest of the five thousand females are celibate nurses and providers. Meanwhile only one in several hundred males is married and he dies on his wedding day. The rest linger on a while, useless. These die of starvation in sight of abundant food, which they have no impulse to eat. The sluggard may learn industry from the ant, but there is little else he need learn. They are an obstinate, intolerant, fatally provincial crowd.

Let us turn then to the branch of animals to which we belong, the back boned animals, and see how, as we rise in the group the care for the young increases. The advance is not always steady. Occasional lapses occur. But on the whole, the trend is undoubtedly toward fewer children and these better cared for.

To begin then with the lowest class of the backboned branch, the fishes, let us look into the life of two of our common fish, with which most of us are reasonably familiar, the shad and the sunfish.

It is a strange hegira that makes its way out of the ocean and up our eastern rivers in the spring time. First comes an abundant stream of fish about ten inches long. In the absence of bigger fish our men put out their nets and catch these and sell them, by the thousands as herring. They are not herring. The specialist in fishes knows them as "alewives" though why I cannot guess. But suddenly all herring fishing is abandoned, though these fish are still plentiful. The shad are here. Where a herring now would bring a few cents a shad will sell for a dollar, and for a month or so all the nets are shad nets. When this wave has passed a third, little known to the general populace, comes on. This is made up of menhaden. These are said to be "too oily to eat." I doubt not some one will some day tell us how to prepare them well, and these also will grace the market. When the shad came to New England in early days they were despised in favor of cod. As yet, however, the menhaden are caught in enormous quantities and ground up for fertilizer. Let us turn then to the much loved shad.

Visitors to the Jersey seashore resorts are usually astonished to see, a mile or so out from the land, posts

sticking out of the sea. These support the "pound nets" which have made of sea fishing a corporation business, instead of one that anyone with a boat and a net can follow. These posts cannot be more than forty or fifty feet long, at most and show us that the ocean must grow deeper here very gradually. The truth is this gentle slope runs out for a distance, varying at different points, from ten to fifty miles. Then the bottom descends quite abruptly to a mile or more in depth. This ledge of land so slightly under the water is known as the continental shelf. It is the home of the great mass of crabs, lobsters, clams and such like, and of the sea weeds. Beyond the shelf the water rapidly grows too deep for plants to get sun light, and the whole character of the bottom life changes. The animals which keep near the top, or come often to the top, may be like that along shore, but deep sea creatures are fantastic.

Now in that water, beyond the continental shelf the shad live, for the greater part of their lives. For the first three years of their existence they spend all their time there. In later life (and a shad is old at seven years) they live there from July to March.

As spring comes on, the adult shad, impelled by a strange urge, swim up upon the continental shelf and approach the mouth of the river. They go almost always to the stream from which, as little fish, they descended. They haunt the mouth of the river, held back by the coolness of the water. When all the ice and snow is gone from the headwaters, the river water gets warmer. Now the shad start up stream. Their progress is very slow because they are under an instinctive drive, that compels them to swim against the current. The flow of the water,

in the lower reaches of a stream emptying into the ocean, changes its direction four times a day.

When the tide is rising, the water dams back. I never realized that it actually reverses its flow until one winter day I was crossing the Delaware between Philadelphia and Camden, I saw the ice cakes moving up stream. Often since then I have watched to see the floating débris move up. The tide comes in and goes out twice a day. When the water comes down the shad swim up; but when the water slackens and then for a time runs up the shad similarly slacken and then run down. Hence it may take them a month to get from Cape May to Trenton. Here they get to the head of tide water. Above this their course is rapid. They scatter to all the ripples from this point to beyond Port Jervis, where shad were well known in early days. I remember as a boy the shad nets at Easton. The mile long net at Gloucester was boasted of as a curiosity, up to a few years ago. Now shad nets are few anywhere in the Delaware.

When the shad reach a ripple, and some shad students say the ripple on which they were born, some of them end their journey. They find a stretch of coarse sand and pebbles at the base of a ripple, where the bottom is sure to be clean and the water, after leaping over the rocks, is certain to be well stored with oxygen.

In the late afternoon the female, or roe shad, heading across the stream discharges slowly the multitude of eggs, which being slightly heavier than water, sink amongst the pebbles. It is said a full grown shad may contain four hundred thousand of these eggs. Anyone who has eaten "shad roe" must realize that the number, in two sacs of such a size, must be enormous. Again, driven

by his instinctive urge, the male swims just behind the female, almost nose to tail, and he discharges the sperm cells, which must outnumber the egg cells a thousand to one. Each of these is motile, and wriggling about in the water is chemically attracted to the egg.

Doubtless the latter flavors the water in its vicinity. The head of the sperm cell, with its nucleus, containing the determiners of the father's qualities, enters the egg cell and there fuses with the nucleus of the egg cell containing the determiners of the mother's qualities. The new life now begins. It is born of two other lives, and is a compromise between them. It is nature's hope that it is an improvement on the two to which it owes its origin.

Having laid her eggs, up the river, away from the excessive danger to young fish of the populous waters of the edge of the ocean, the female has done her part. The male, having provided his share of the qualities has done his full duty as a shad. Now both father and mother abandon the eggs and return to the sea. It has been a strangely devoted mission. These two have had nothing to eat since they left the ocean. They eat nothing they can find in fresh water; or perhaps their instinct drives them to forget their hunger until they have discharged their germ cells. In any event, no shad is ever caught with hook and line, and the shad's stomach at this time is always empty.

The eggs, so far as they have been fertilized, and probably most of them failed of this good fortune, slowly develop. Gradually head and tail are lifted from the globe and the fish swims feebly about with a big hump of fat yolk on his abdomen. This grows less and less as

he grows larger and larger. By the time it has all been absorbed, he is able to swim actively and his digestive system is ready to handle the food he can now gather for himself. Their parents had retreated in June. The young follow about October, being then about four inches long. Of the four hundred thousand eggs, perhaps half were fertilized. Of these, say three fourths were bruised by moving pebbles when the water raised a little after the next rain. Of the remainder which began to swim, about nine tenths were eaten by larger fish. If our guess (and it is but a guess) is right five thousand, of the four hundred thousand, start for the sea. By the time this is reached the number is probably down to one thousand.

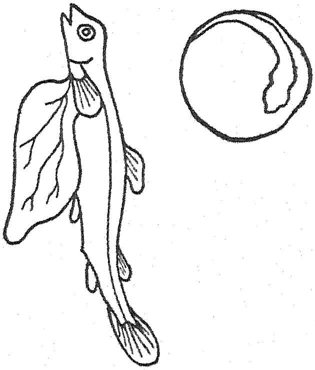


FIG. 37—Egg of trout, partly hatched, and young trout with attached yolk.

These must grow for four years, out in the dangerous ocean, before they can take up the journey. By this time the thousand must be on the average down to one hundred. By the time these get to the ripple and lay their eggs and thus complete the cycle they must average only two—replacing their parents who have now dropped out. It is a tremendous loss, an overwhelming loss.

As we come up the scale of fishes we find a much better state of affairs. Let us visit the shallow pebbly flats along the edges of our ponds and lakes, or the pebbly pools of our little streams. July has just come in. The

water is haunted by our most beautiful of fresh water fishes, the sunfish. I can hear the groan of a trout fisherman but I will not take it back. This little dandy is beautiful, so that he may win the attention of his lady

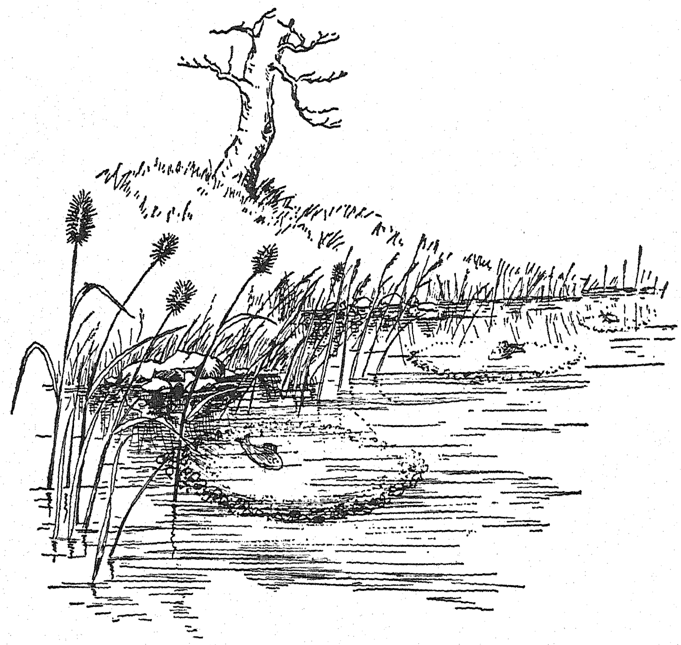


FIG. 38—Sunfish over their nests.

friends. During the mating season his colors glow with a brilliance much beyond that of the later summer.

The male chooses for himself a location near the edge of the pond. If there are a few rushes about so much the better. The water must be only a few inches deep. Patiently he begins to clean up a spot. He picks up each pebble, mumbles it in his mouth until he clears it of any

scum of green algae which might cover it, and tosses the stone out again, clean. He picks these pebbles chiefly from the center of his location and tosses them out again towards the edge. In this way he builds a rampart about the edge and a depression in the middle, making a clear circular nest about the size and depth of a breakfast plate.

Meanwhile other sunfish have built neighboring nests until there may be a dozen within an area of five feet each way. Over each nest swims the guardian male. Each must respect the territory of his neighbor. Should he invade it, he will be driven off by the owner, who is absolutely master of his domain. The latter, however, is equally unwelcome on, and as surely driven off, his neighbor's nest.

After a few days of watchful waiting the females begin to appear. Whether there is any prearrangement I cannot say. Perhaps the choice is made on the spot. In any event, after a little time spent in chasing each other about the nest, the colors of the male gleaming, they settle down to the matter at hand. Now they swim closely and slowly side by side, the under side of their bodies slightly inclined toward each other. The egg cells are discharged by the female and the sperms by the male at the same time, and both settle on the bottom.

Now the female retreats and leaves the male to care for the eggs. He does nothing except protect them, but he does that effectively. Any fish, no matter what his size, who approaches is attacked with a promptness and an audacity that sends him away at once.

The number of eggs deposited is probably only a few hundred, instead of many thousands as in the shad. But

each egg is larger, so that the embryo fish has more food to grow on, and the care is so effective that of those few hundred as many grow up to replace the parents, on the average, as there do of shad.

For the male keeps up his vigil until the little sunfish are nearly half an inch long. From this time on they take care of themselves. Here is real parenthood. Strange to say, amongst the sun fishes it is father on whom the burden chiefly falls. There are far fewer children started, than in the case of the shad, but in the end the effect is the same. Enough mature to replace the parents.

The step above the fishes in the backboned group is held by what the scientist calls the amphibians. This is because, while young, they live in the water and breathe by gills entirely like fish; in later life however they develop lungs and come out on land, some occasionally like the frog, others habitually like the toad. There is thus a very considerable advance to these creatures over the fishes. Instead of fins they get, as they grow up, legs, of which in the frogs the hind pair are webbed for swimming in water, and long and strong for leaping on land.

In spring there is an interesting hegira of all of this tribe to the water. Whether they are common frogs, tree frogs, or toads, all instinctively feel that their eggs must be laid in water. So from every side the toads and tree frogs approach any pond. In late March in the latitude of Philadelphia we hear the first of the spring love songs of this big group. It begins with the "peep, peep, peep," of the Pickering's tree frogs, popularly known as "knee-deeps." After they have been going for a time, the toads open up with their purring "eh-eh-eh-eh-eh." When the knee-deeps have closed and the toads are still

purring, the spotted frog starts his "chuck, chuck, chuck." When all of these have long since mated, and July is well begun, the last of the frog songs booms across the meadows in the full, mellow "mohr-rump" of the big bull frog.

These are the mating songs of the frogs and they each have their own so as not to mislead the species in the dark. For in the case of most of them the mating is done at night, though the toads seem to mate equally in light or in darkness.

While the eggs are being placed in the water, the female pours out with them a very thick tough jelly that swells when it gets wet. If it is the frog which is laying the eggs, they are put in clumps of several hundred. This jelly consists of a very bitter mucus and keeps the eggs safe from fish, who would gladly eat them. If the toad is doing the laying, the mucus forms in long strings, dotted with a single line of eggs.

The fertilization of these eggs is a much surer and less wasteful process than is the case with fish eggs. The male, who is quite the smaller, because he need not carry the great burden of the eggs, approaching the female from the back clasps her under her arms. Then as she discharges the eggs, he does the same for the sperm cells, pouring them over the emerging eggs. Often by this process every egg laid is fertilized, and it is rare for many to escape. The frog's egg is so big, and because of its jelly so often noticed by people, that I shall describe here the development of such an egg. The process, in its earlier stages, is much alike for all animals, above the lowest, and varies more in the later stages, as you come up the animal scale.

At first the egg is one big cell, its size being simply due

to stored food, largely fat, which the mother placed in the egg. This fat is found chiefly in the under side of the egg which on the frog is light colored, the top being dark.

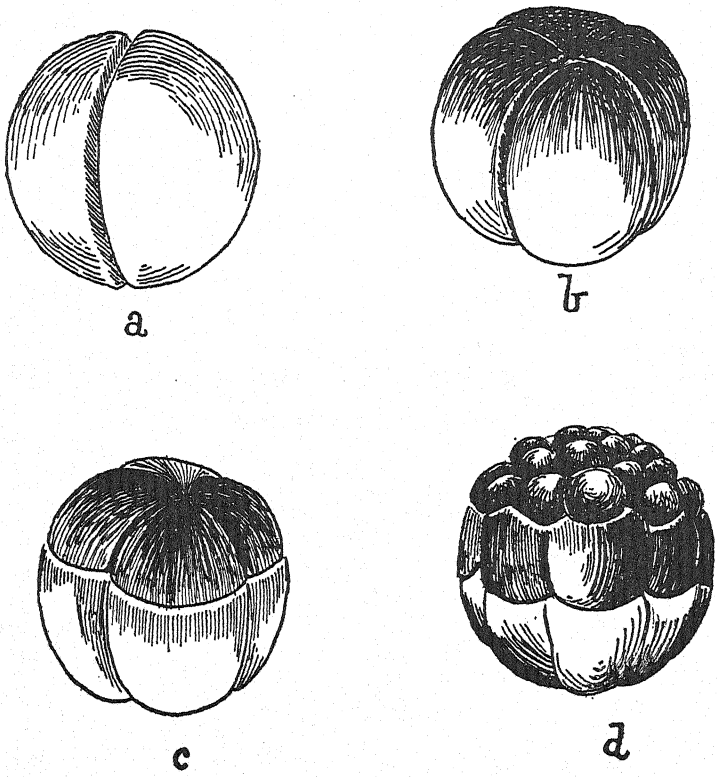
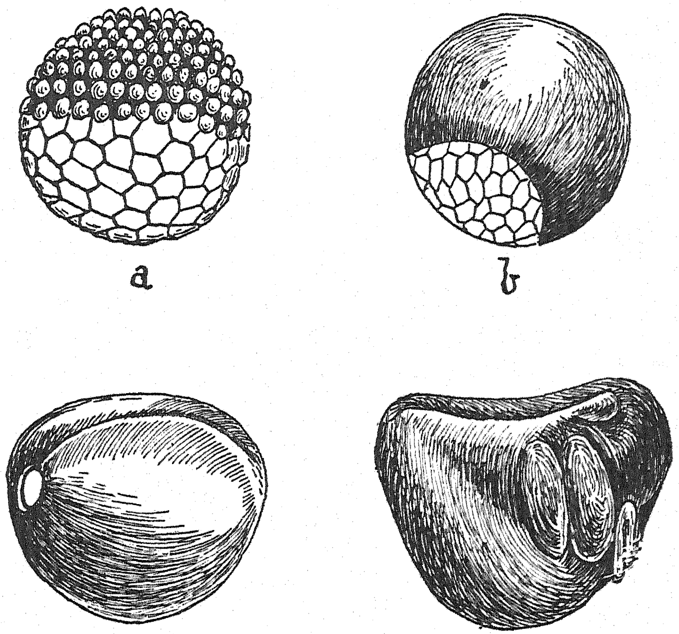


Fig. 39—Erly stages in the development of the frog's egg. *a*—Two celled; *b*—Four celled; *c*—Eight celled; *d*—Many celled.

This color scheme helps to hide the eggs from observation by their enemies.

The first steps in the development are called cleavage stages, because the egg splits into two, then four cells.

The next split cuts four upper, darker, smaller cells from four, lower lighter colored, larger cells. From this time on the top divides for more rapidly than the bottom, this



a b c d

FIG. 40—Later stages in the development of the frog's egg. *a*—Hollow ball stage; *b*—infolding ball stage; *c*—groove of nervous system forming; *d*—Limb buds and sucker showing.

latter being probably slowed up by the abundant fat. The rapidly multiplying cells gradually spread over and engulf the fewer large cells. They leave within the egg a cavity which will be the alimentary canal. Now a groove forms along the top, sinking in like a deep narrow gutter. The

upper edges of the gutter push over until the two sides meet and convert the gutter into a pipe of skin under the skin. This is to be the central nervous system. Its forward end swells and folds into the brain. Now ridges appear on the side of the body which will eventually become legs. Then a sucker forms on the head. Now the animal emerges from the egg. The creature is still living on the yolk. Its mouth is apparently a later addition as is the rectum. These both start as indentations of the outside surface and push farther and farther in until they join the primitive canal, making it a continuous tube from mouth to vent. Now the creature can move about and eat. Its legs are hardly quite as prominent as they were earlier and the animal seems all head and tail. Gradually however, the legs appear; the hind legs first, later the front. These appendages seem to dangle for a time. Soon they grow firmer and are used in swimming. Then the tail begins to be absorbed. It grows less and less and finally disappears, the tissues which once composed it being absorbed, transported and used as building material, in other locations in the body.

There is an interesting difference between the frog and the toad in the course of the development. Because the toad is land living, the pool it strikes in which to deposit the eggs is often small and liable to dry up quickly. Hence the toad hastens through its development without waiting for its growth. A frog grows steadily but develops very slowly. Hence the spotted frog is two inches long and several months old before it loses its tail and takes to the land. The toad hurries through its development, absorbing its tail and taking to the land within a few weeks, when it is hardly more than a third of an inch long.

When the creature takes to the land it naturally selects a time when there will be the least change in the conditions; that is, when the ground is quite wet. So it happens that when in April or early May we have a warm

FIG. 41—Development of the frog after leaving the egg.

rain, the little toads swarm out over the ground. Then the wiseacres tell us "it rained toads last night"—which it never does excepting after a cyclone when it also rains haystacks.

With this conscious calling and mating of the frogs we have a much higher state of affairs than we saw in the shad and in some ways higher than in the sunfish. The eggs are very large, compared with those of the fish. This means the young will be larger and will have had a longer development before they need forage for themselves. The bitter jelly in which they are imbedded serves as a material protection while the jelly itself makes the mass large and less likely to be washed away with rising water. Besides this the toads tangle their strings of eggs amongst the water plants and this also helps to preserve them.

Here then we see a still further advance in the line of a smaller number of young and better care taken of them. Fewer are wasted in securing enough to replace the parents when they move off the stage.

CHAPTER V

TURTLES, BIRDS AND THEIR YOUNG

IT MAY seem strange to one not a biologist to find reptiles and birds considered together. As a matter of fact, different as they seem, there is a most intimate relationship between them. This one might guess looking from the scaly legs of a lizard to the scaly legs of a turkey.

In the far more essential matter of the structure of the egg, they are particularly alike. All their big differences are tied up with the fact that one group is cold blooded and the other warm, very warm, warmer by about ten degrees than we are. Reptiles are really a higher development of amphibians. They have shoved their whole water-living tadpole-like stages of development back into the egg. Hence as soon as they are hatched they are ready to live in air instead of in the water. This makes a better protection of the egg necessary. The frog in the water does no inconsiderable part of his breathing by absorbing oxygen through his skin. Only a moist outside layer can do this. The reptiles have better lungs and depend on them more exclusively for absorbing their oxygen. Hence they can afford to wear a sort of armor. The epidermis humps up into scales which cover the reptile from head to tail.

The central amphibian, from which the rest were derived, was in form much like our salamander or newt.

This is the creature in the springs and small creeks that the children mistakenly call a lizard. The newts have smooth, moist skins and knobs on the tips of their toes. Lizards have dry scaly skins, live in air, and have claws on their toes. In other words newts are amphibians and lizards are reptiles. The center of the reptile group had the form of a lizard. From him have developed all the other kinds. Snakes are elongated lizards that have lost their legs. Turtles are shortened, broadened, flattened lizards whose ribs and backbone have spread until they touch everywhere and make a shield for protection. This forms the white bony case under the scaly outside layer in the turtle's shell.

The day of the reptile is largely over. In an earlier geological age (the Mesozoic) these creatures flourished most abundantly, and some of them were of enormous size. They roamed the land, they waddled about the swamps where they grew to be seventy feet long and twenty tons or more in weight. They took to the ocean (as the whales have since done) and they flew in the air like great bats. It is of course a matter of conjecture as to what influences wiped out these masters of the then earth. It seems not unlikely it was a question of a change in the climate. The Mesozoic was a time of greater warmth over the entire earth, showing palms and ferns as high up as Greenland. Reptiles love the warmth. Under high temperatures they are active, in cold seasons they become inactive and often dormant. With the close of the Mesozoic came a cold season which was most hostile to reptiles and gave a tremendous advantage to the warm blooded birds and mammals who were then just beginning to develop out of the reptiles. With the coming of the next geological age, the Cenozoic, we have the rapid development of the birds and

of the mammals, neither of whom existed in any clearly defined form in the Mesozoic or age of reptiles.

We may then think of the reptiles as amphibians which have become adjusted to spending their life on the land, and breathing air from the time of hatching from the egg. To make the subject seem more familiar we will take one particular kind of reptile for our consideration, and that the familiar turtle.

This creature lays its eggs in a hollow place it has dug in the ground. It uses its front claws to make a hole in the earth about a foot deep, deposits its eggs in the bottom of the hole and covers them with earth. The egg is shaped like a plum and indeed has very much the feel of a plum. It is covered with a tough coat which is slightly flexible under pressure. The size varies of course with the kind of turtle, being for our common small turtles about an inch long and a little more than half an inch through. This cover to the egg is necessary because it is to be laid in the ground. If the egg had the slight skin of the fish's egg or the jelly and very thin skin of the frog's egg, it would dry up in the ground, and not unlikely become infected by bacteria. Both of these dangers are avoided by the tough coat which covers the egg.

Because of this coating, which it quite impervious, it is impossible for the male to add the sperm to the egg for fertilization, after the egg is laid. Hence it becomes necessary for the male to inject the sperm cells into the egg tube (oviduct) of the mother. Once inside the tube, the tail of the sperm cell with its wriggling motion carries the cell up through the mucus which lines the pipe. Well up towards the upper end it may meet the egg cell with which it fuses. This egg, which has but recently left the

ovary, is many times as large as a fish or a frog egg. It has been gorged with fat and albumen for the nourishment of the young which is to remain long inside the shell. This is because it must pass through its earlier, water breathing stages and must develop its lungs. The egg at this point is only what, in the final form, is the yolk. The albumen, or white of the egg is secreted upon the yolk by the walls of the tube as the egg passes down. The lower part of the tube toughens and somewhat hardens the shell with its secretion of lime.

So the eggs, about eighteen in number are placed in the cavity and abandoned by the mother. But the egg is in far less danger than is the egg of a fish or of a frog. Drying and infection are prevented by the shell. The fact that the eggs are concealed under the ground makes it less likely that they will be found and eaten by other animals. The inside structure of the egg during its development is such that the delicate embryo is well guarded against shock and has abundant food and full access to oxygen. This arrangement is the same as that in the egg of the birds. The structure of the hen's egg is so much better known to most people than is that of the turtle, that it will be described in the later part of the chapter when the development of the chick comes up for consideration.

We have in the reptiles a splendid example of the fact that as animals rise in the scale of life there is a marked tendency towards the production of fewer young and a higher degree of protection of those born or hatched.

In shad we found four hundred thousand young cast loose on the world of the waters. The sunfish produced far fewer but tended to them. The frogs produced several hundred eggs with much more nourishment stored in them.

Reptiles produce a score or so of well protected eggs, finely nourished and hidden in the ground.

Towards the end of the Mesozoic Age some of the reptiles grew a partition down through the center of the ventricle of the heart. The ventricle is the pump whose contractions drive the blood over the body. In the amphibians like the frog this pump had two inlet chambers (auricles) one receiving the partly used blood from the body and the other the freshly oxygenated from the lungs. These two streams entered the one ventricle and then a single pipe received the blood from this pump and distributed it both to the lungs and to the general body. But with the reptiles the partition which separated the inlet chambers continued down through the pump, cutting it into two parts, from each of which ran an outlet tube. Now the right side of the heart, receiving the used blood from the body sent it direct to the lungs to throw off its wastes and to gather fresh oxygen; at the same time, the left side, getting from the lungs the blood rich in oxygen sent it out fresh to the body. This made possible a much higher type of combustion, and the animals became "warm blooded" as it is called.

But quite as striking as the warmth of the blood is its even temperature. The reptiles, while called cold blooded, are cold when the air in which they live is cold, and are warm when the atmosphere is warm. A black snake, lying on a rock in the sun may get so hot as to be uncomfortable to our touch. On the other hand, in the winter this snake will get to be so cold as to lie stiff in an absolute stupor.

But the birds and mammals have a nervous heat-

regulating system. This turns on the heat when they begin to get cold, by increasing the combustion. When the temperature is restored to the entirely normal the combustion is checked. So any particular bird has always, in health, the same temperature. This varies somewhat in different kinds of birds from about one hundred and five to a hundred and eight degrees in many common birds up to one hundred and twenty in the case of the restlessly active chimney swift. The mammals have a very similar heart structure, and a similar heat controlling mechanism, but the temperature runs only to ninety-eight or one hundred; in human beings it is normally ninety-eight and six-tenths.

To maintain this temperature, clothing is necessary. Hence the scales of the reptiles are converted into feathers in the birds, or give place to a new coating, the hair, in the mammals.

Because of the warmth of the body temperature of young birds and mammals the eggs must now, for the first time in the development of the animal kingdom, be kept warm. To do this birds build nests and then, with their own body heat keep the eggs warm by sitting on them. The mammals keep their forming young warm by retaining them within the body of the mother. Let us then first turn to the birds, leaving the mammals for the next chapter.

It would seem as if the emotions were more active, in warm blooded creatures than in cold, as indeed are almost all their functions. In fishes, frogs, or turtles it seems an entire travesty to speak of love. Not so with the bird. Here the joy of courtship is often very evident. The songs of many birds are most attractive,

and the arrangements for securing the attention of the mate are often quite conspicuous. Just because we are so much more familiar with chickens than we are with any other bird, I will take them as my example.

Here the beauty of the male, rather than of the female is very striking. The big comb, the sickle feathers over the tail, the brilliant coloration of the body feathers which, at least in the native bird, are red, orange, green, brown, all in the same bird, make him a most striking object. The female, who because she sets must be less conspicuous, again in the wild type, is quite modestly inconspicuous. This contrast between male and female is not uncommon in the birds. In the chickens, however, it is emphasized by the polygamous habit. This requires that the male should be able to attract a number of females and drive off a corresponding number of males. This gives the cock his belligerent disposition and his challenging voice as well as bright feathers.

Because the young are to be early exposed to the air they are in a covered egg; and because this egg is to be kept warm by the mother's body, it must have a more abundant stiffening of lime in its coating. This makes it necessary that the egg be fertilized within the body of the mother. The male places the sperm cells within the mouth of the oviduct or egg tube and they swim up to where the egg has about it as yet neither shell nor white. It is still all yolk, as it came from the ovary. Any one who has ever opened a chicken and taken out the entrails has at some time found in an old hen an ovary with eggs in every stage of fattening, from the size of a pinhead to that of a fully developed yolk. Here, as in the turtle, the white is secreted upon the yolk

by the walls of the oviduct and at the very bottom of the tube the lime is put into the shell. Occasionally a hen, pushing herself under a fence cracks to pieces the shell of an egg which is nearly ready to be laid. Before it is protruded, the wall of the tube has secreted on it more lime and the shell is completely repaired, though it looks like the terazza floor in a bath room.

This big egg needs a suitable place for its preservation. It is so rich a piece of nourishment that many animals are glad to eat it if it is not hidden from their notice. Sea birds on an inaccessible and rocky island can lay eggs in plain sight on the rocks but most birds must hide them. The owls place them in hollows that decay has made in the trees. The wood peckers dig out for themselves big nests in the dead wood of a tree. Kingfishers and bank swallows dig holes in the side of a bank. Most of the birds, however, gather twigs, slivers of bark, rootlets, grasses or some such material. These they fit together, shaping them by sitting down in the nest and rotating their bodies. In this way the nest gets round and of proper size for the bird's body.

Within these nests, the mother lays her eggs. In the sea bird's protected nest one egg or two will be enough for safety. In the ground nests not too well hidden, of ducks and chicken-like animals, ten or twenty are none too many. In well protected tree nests five is a common number. When she has her full set, the mother bird begins to sit on them to keep them warm. If she sat on them as she lays them and since she lays them about one a day, they would not all come out together. So she waits for the full set, then warms them and gets them all through on the same day. The moth-

er's body does nothing for these eggs but keep them warm. Hence it is quite possible to put them into an incubator and hatch them there by artificial heat. It is easily possible for the scientist to take eggs out of an incubator one by one and, breaking them open, study the embryo at varying stages of its development. For our purpose, however, an egg at about twelve of the

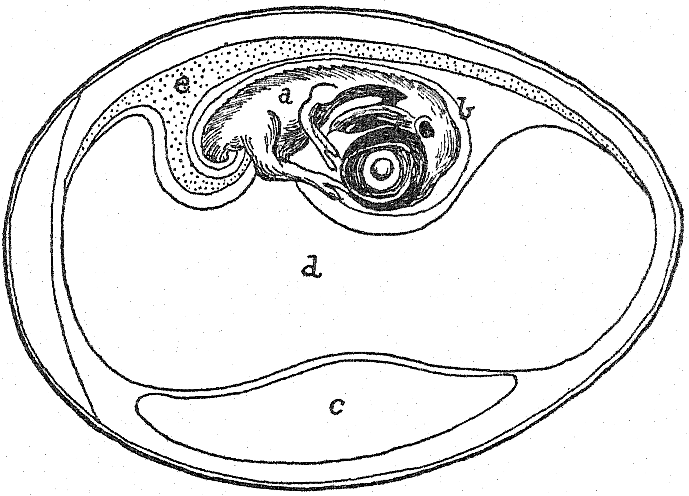


FIG. 42—Embryo chick in the egg. *a*—Embryo; *b*—Amnion; *c*—White of egg partly absorbed; *d*—Yolk; *e*—Allantois for respiration.

twenty-one days it takes a hen's egg to develop, will serve very nicely.

On the outside is the shell, hardened with lime, so as to bear the weight of the hen without injury to the embryo on the inside. Beneath this hard shell and closely attached to it, is a leathery membrane. These two separate at the blunt end of the egg, and form an air sac.

As the chick develops, the material within the egg becomes more compact and not a little of the water evaporates. As the fluid and solid contents become less the air bubble grows larger. In the end, it gives the chick its first chance to fill its lungs, before breaking out of the shell.

The interior of the egg has by this time formed into a quite complex environment for the growing chick.

The embryo itself will readily be distinguished in Figure 42. By the twelfth day it is quite clearly bird like, though in its earlier stages it looked much more as if meant to be a fish, having slits in the side of the neck. But these have closed long before the twelfth day except the one that has been transformed into the ear cavity.

This embryo is most marvelously delicate and might easily be injured by any jar except for an effective protection. Around it has grown a "bag of waters" (the amnion with its contents). Inclosed as it is in a fluid that fills the bag entirely, jars are very much softened. The creature grows up inside an hydraulic shock absorber. Even so young a creature as this must have food and oxygen. The food consists of the white and the yolk of the egg, excepting the small spot on the top that develops into the chick. These are absorbed through a series of blood vessels leading from the chick over the yolk and back into the chick again. This blood circulation absorbs gradually both the white and the yolk of the egg until by the twenty-first day all have gone to make up chick. Another set of blood vessels runs out from the chick, passing up the handle and spreading all over the surface of a great umbrella (the allantois) which

floats against the inside of the egg shell above the chick. Through this shell the blood in the allantois absorbs its oxygen and throws off its wastes. There is a tendency for this delicate membrane to grow fast to the shell. Hence the hen, or the owner of the incubator, must frequently turn the eggs.

There is an interesting difference in the length of time during which different birds remain in the egg. The hen's egg requires twenty-one days. The ancestral hen (the Burmese Jungle Fowl) lays its eggs, about a dozen in number, in an only moderately protected nest, on the ground. Hence she lays eggs, with nourishment enough in them to support the young until they are able to run about and take more or less care of themselves.

The robin, on the other hand, with its well protected nest, placed in a tree or on a ledge, lays but four eggs, and these only large enough to support the growing embryo for thirteen days. Hence when it emerges from the egg the young robin is exceedingly unfinished and needs to receive the utmost care from its parents.

With the warmth of the young bird's blood, and hence the necessity on the part of the mother bird that she devote herself to the care of the young, there comes a remarkable development of affection for these young. This makes it most interesting to watch the courtship of the birds, their nest building, the incubation of the eggs and the subsequent care of, and in a sense the training of, the young. There is no such devotion amongst any but a very few fishes, frogs, or reptiles, and when there is, it is because of the helplessness of the young at birth and their dependence on the care of the mother.

With the coming of the egg shell came real mating between the parents. But with warm blood has come what seems really worth calling love, both parental and to a less degree, conjugal. There is here real courtship and actual married life.

CHAPTER VI

THE MILK GIVING ANIMALS

WHEN people who are not familiar with the literature of science, speak of animals, they usually mean this particular group, the milk giving animals, the mammals. These are the animals, which, from glands on the chest in a few kinds, or in most of them on the abdomen, secrete milk for the nourishment of the young. While evolution was slowly winning acceptance from men of science and the idea of "special creation" by God direct held sway, it seemed not unnatural to think that evolution might explain the relationship between lion and tiger, perhaps even between cat and dog. But the gap between cat and cow seemed too thorough to be bridged. This seemed particularly true in the case of the gap between the milk giving animals, and all the rest. Their method both of producing their young and of nourishing them after birth seemed so unique as to demand a special act of a creative God. Our understanding of that gap has been greatly enlarged since then and now the scientist understands that God created the mammals just as he created all the rest of the animals, by gradual alteration from other animals.

The last ancestors of the mammals are some of the reptiles of the Mesozoic or Age of Reptiles. There was a group of these animals who are known as Theromorphs

which mean having the "form of beasts." From this group, if the students of fossil animals are right, have descended the mammals.

The essential part of the change came in the structure of the heart, as described in the case of the birds.

This altered instrument of circulation permits of much quicker burning of the body tissues and the production of a higher heat than did the old form. There grew up with this change, an added complexity in the nervous adjustment directing the circulation. This acted like a thermostat, the little box on the wall that turns on the heat if the room grows cold and turns it off again as soon as the temperature of the room reaches the point for which the instrument is set.

The nervous thermostat in the human body is set for 98.6 degrees Fahrenheit. Whenever we reach that point the blood is sent to the skin. This makes the skin red and causes the sweat to pour out. The evaporation of this moisture uses up the heat of the surface and thus cools the blood. When everything is right, once more the blood retreats, the skin goes white and the perspiration is largely checked. Should the blood get cool the surface stagnates, may even get blue, more liver sugar is thrown into the blood and combustion increases until the body heat is once more exactly normal.

Hence when the Age of Reptiles closed with a great sweep of almost glacial cold over much of the earth for a long time, the reptiles largely passed out. Two lines of their descendants had learned the trick of keeping their blood warm and hence were destined to a great development in the succeeding Age of Mammals (Cenozoic or Recent Age).

The warm blood of these creatures gave active life, and perhaps it was that which gave them their great power to vary, and hence to evolve into many lines. The bats became adapted to the air, the monkeys to the trees, the whales to the water. The rodents largely went beneath the ground. Others of the mammals however kept to the surface and became grass eaters with hoofs for the plains or flesh eaters with teeth and claws for preying on other animals.

I have mentioned the fact that the mammals seem to have wonderfully perfected their method of producing their young. But after all, it must have been acquired slowly and by gradual steps from the method used by their reptilian ancestors, as described in the last chapter. We have come to know these stages by finding belated animals that use them to-day.

In Australia is found the duck mole. It has a life much like that of our muskrat. Swimming in the water, it digs into the bank of the stream. Having entered the ground, it burrows upward and forms a considerable cavity above the level of the water. This is its home. It is a warm blooded, hair covered animal, but it lays a small egg, with a hard shell and sits on it to keep it warm. The young when born feed on the mother's milk of which we shall have more to say later.

A step higher up stand the Kangaroo and the Opossum. Here the egg is kept inside the body for a short time, then hatches and its enclosed embryo is born. But it is so small and helpless that it is put into a pocket over the mother's teats. Each young finds a teat and fastens to it. The muscles of the breast force the milk into the young kangaroo until it is old enough to suck for itself.

When we except these few backward mammals and their very near kin, all the rest on the earth to-day have far passed that process and have won a complicated and very successful method. This of course developed out of the reptilian egg method, altered through the steps just mentioned, to the present plan.

The egg, as it ripens in the ovary, sends out chemical messengers, hormones, into the blood. These affect the mother sharply. They cause the cavity in her body, the womb (uterus) at the junction of the two egg tubes, to grow swollen, and a heavy tender skin to grow over the inside of the cavity giving it a spongy lining. At the same time this hormone stimulates the enlargement of the breast. Reaching the brain, it so disposes the female that she begins to take pleasure in the company of the male to whom before she was entirely indifferent.

If mating occurs, the sperm cells are placed by the male within the body of the mother. The tail of a sperm cell gives it locomotion and its impulse is to swim against the current. There is a steady flow of mucus down the passage and against this the sperm cell swims. Its progress is slow and it may take a week to get into the upper part of the egg tube where it may meet a recently discharged egg.

Should this not occur, and no egg be fertilized, the hormone ceases to be produced, the breast relaxes, the disposition to mate passes away, and the skin is cast off, in fragments, from the inside of the womb, being sent out as a bloody discharge (menstruation). This is the evidence that, for this time at least, natures design was not accomplished.

If however, the egg is fertilized, it passes on down

the tube into the uterus. Here it adheres to the swollen inner lining which soon grows over it. It is still astonishingly small, having about one half the diameter of the period on this page. The sperm cell, head, tail and all has about the same length but its head, the vital portion, has about one tenth the diameter of the egg.

The egg at this time has the structure of the reptile's or chicken's egg except that it has no lime in the shell and has no nourishment stored in the yolk. As the egg lies embedded under the surface of the lining of the uterus, it grows a mossy series of projections from a part of its outside. This mossiness penetrates the fleshy lining which is itself growing heavier. Gradually a pad forms, half mother half mossy surface of the egg, now grown large and protruding from the lining. This spongy mass is the placenta, through which the embryo gets its nourishment and oxygen. After the birth of the young, the placenta is cast off and protruded, and hence is naturally and commonly known as the after-birth.

To understand the evolution of the egg we must remember the structure of the hen's egg as described and pictured in the preceding chapter. It had, after some days of development, the embryo itself, surrounded by the amnion (bag of waters.) Below it was the yolk over which the blood vessels of the embryo ran to pick up nourishment. These blood vessels passed out of the swelling of the abdomen. At the same point another set of vessels ran up the handle of the umbrella (allantois) and gathered oxygen through the skin and shell of the egg.

All of these features are present at the same stage of

the development of the mammalian egg. The embryo, as before is within a sack of fluid. Beneath it is the yolk sack, as interesting testimony to its past history, though it has in it no yolk whatever and soon shrivels and disappears.

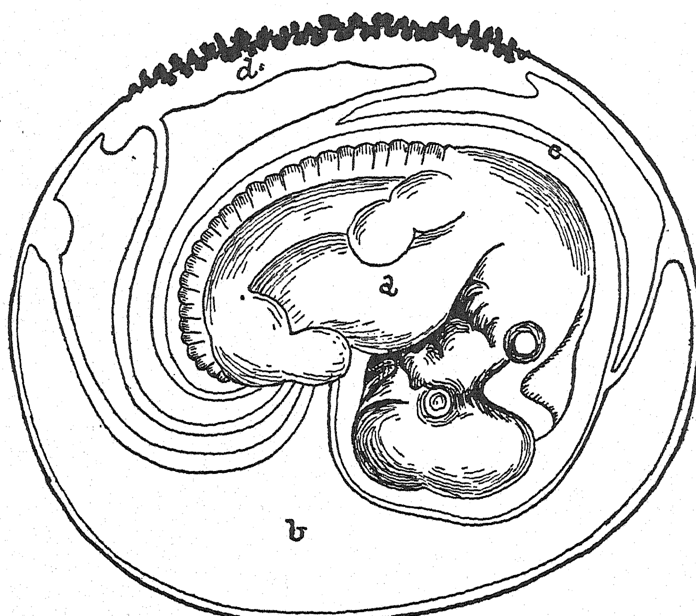


FIG. 43—Embryo rabbit in the egg. *a*—Embryo; *b*—Empty yolk sac; *c*—Amnion with protecting fluid; *d*—The placenta.

Above the embryo grows the allantois, pushing the skin of the egg (chorion) against the skin of the inside of the uterus. It is this chorion, pushed out by the allantois, and having the allantois for its inner lining, that grows mossy and forms with the heavy patch on the inner lining of the uterus the placenta. Into the root

like fibers of the embryo's part of the placenta run the blood vessels of the embryo, the artery becoming numerous capillaries and returning as a vein through the cord and entering the abdomen. Thus the developing animal is connected with the blood supply of the mother. But it is an entire mistake, and one that is common, to think the blood of the mother flows into the young. The blood of the embryo runs into the spongy placenta. But there is no opening anywhere between the mother's blood vessels and that of the embryo. Food and oxygen soak out of the mother's blood, through the walls of the embryonic vessels and are carried to the growing creature. Wastes soak outward into the mother's vessels and are carried away. But every corpuscle of the young blood is its own, formed in the young body and descended from the egg. Furthermore, it is not a mere soaking as through an inert wall. The capillary wall chooses what it shall take and what reject.

Meanwhile a jelly-like mass (the corpus luteum) fills the opening in the ovary from which the egg was discharged. This body throws into the blood a hormone which causes the breasts to enlarge. In the last stages of the development it is probable the embryo itself throws off another hormone. This wherever it may come from, stimulates the breasts to the secretion of milk, thus turning on the supply just in time for the needs of the new born animal.

How long this pregnancy shall last depends on the life of the animal. It is a drain on the mother, which should be ended as soon as is safe for the young. Rats and mice, living in burrows where the young can more easily avoid danger carry them for twenty-one days.

These baby rats look pitifully immature when born, being hairless and the abdominal wall being so thin that the entire outline of the intestines is clearly visible from the outside.

The dogs and cats, in a state of nature, live in dens and are provided with pointed teeth and with a ferocious disposition. They can protect their young. The mother carries them for sixty-one days. The young are born with hair but with unopened eyes.

Cows, whose home is naturally on the plains, where hiding is a matter of much difficulty, keep the young within the body for two hundred and eighty days. By this time the calves are quite large, and able to stand on their feet at birth, even to walk about.

The human infant is also two hundred and eighty days old at birth. But development here has not been nearly so rapid as in the case of the cow, and the human baby is much less mature than is the calf, though more than the puppy and far more than the baby rat.

When development has reached the proper point, in that particular animal, some hormone, not unlikely the same one that orders the flow of the milk, starts rhythmic contractions of the wall of the uterus. These continue for a little while and then for a longer period they cease. The embryo is pushed usually head first slowly down through the neck of the uterus into the tube beneath.

These contractions become more vigorous as time goes on. Finally the sack (amnion) in which the embryo is encased is ruptured. The enclosed fluid, very like that in a "water blister," lubricates the narrow opening to the outside and final contractions push the young

creature into the outer world. It is usually still attached to the placenta against the inner wall of the uterus by the cord, which in the human being is about eighteen inches long and as thick as a slender finger. In some animals the birth ruptures the cord. A dog, or cat, bites it off near the body of the young. The new born creature is usually licked clean by the mother.

Meanwhile the uterus makes a few more convulsive contractions and sheds the inner wall of the cavity, chiefly the placenta and it is protruded. This is so regularly eaten by the animal mother that I doubt not it contains hormones favorable to whatever else needs be done.

When the young animal is born its lungs have never been used and the air passages are more or less clogged by mucus. The cold air against the body that has never know cold before, stimulates it to a sharp cry. This clears the passages and respiration begins.

Instinctively the young feels for the breast of the mother. The first milk (colostrum) that comes is of peculiar character and stimulates the food canal of the young animal to discharge the accumulated mucus. Soon the character of the milk changes and becomes for a longer or shorter time the entire food of the animal.

Naturally we wonder what is the origin of this remarkable food which is so characteristic of the mammals, that the organ which produces it in the human being (breast in Latin is mamma) gives the name (mammals) to the group.

I remember my astonishment in my early teaching days at a condition I found when I skinned a cat for

use in my physiology class. The animal had evidently been nursing kittens, and its breasts were enlarged. My surprise was great when I found these breasts came off with the skin. I had expected them to remain attached to the body. It was plain they are modified portions of the skin. Now there are regularly in the skin two kinds of glands (Fig. 23). One of these is a long slender tubular gland, rolled up at the lower end into a sort of knot. This secretes perspiration. The other kind of gland is more like a glove with fingers emptying into a slender hand, and finally pouring out an oily secretion at the base of a hair, serving to keep the hair and skin oiled, thus making them soft and flexible. Out of one of these two glands the milk glands must have evolved. The anatomical evidence seems not to be quite clear, and specialists, I find, are divided in opinion. I am not a specialist in that matter, but I venture the suggestion that between a gland that throws off wastes, and one that pours out oil, the probability is in favor of the latter.

In any event, milk is a secretion built up out of materials selected from the blood by the gland and poured out for the use of the young. Each portion of the gland has a long enlargement of its discharge tube. In this the milk collects. There are many such tubes and when they are well filled the breast (or udder in the cow) becomes swollen and tense. The openings of these tubes lie in the prominence of the breast, fitted for the attachment of the young lips.

There is a marvelous psychological result of all this intimacy of relationship between the mother and the young. There grows up a devotion of the mother to the

young which is one of the most intense, and most utterly altruistic emotions known to the animal world. A dog, who is so small as to be ludicrous under the conditions, will attack ferociously any person or other animal who attempts to interfere with her young. It is this emotional attachment of the mother to her young that in the human species gives the power and dignity and value to human infancy, to be described in the next chapter.

CHAPTER VII

THE MEANING OF INFANCY

It was in the seventies of the last century that the American historian and essayist, John Fiske, an early convert to the theory of evolution, taught us to realize the real significance of the lengthened period of the helplessness of the human infant. Furthermore, the duration of this time increases steadily with the growth of civilization. My daughter's collie was a mother at one and a half years of age and a grandmother at five and each period could have been shortened by half. We have just been shocked by a description of common wifehood in India at eleven and motherhood at thirteen. With us wifehood is unusual enough to be striking at eighteen and motherhood at twenty.

How does all this happen and what is the result? The word infancy means to most people babyhood. There is a meaning of the word as used in the law, that corresponds more nearly to the sense in which I wish it to be thought of in this connection. Infancy both in the actual derivation of the word ("not speaking"), and in the law means the time during which a boy or girl is responsible to the parent who, before the law must "speak" for them because they being "infants," can "not speak" for themselves.

We have arbitrarily, and probably quite wisely, set

that time in the United States at twenty-one years of age. Until then no boy or girl can validly dispose of property or be married without the parents' consent. In this chapter and in several following we will think of infancy in this sense of the period between birth and the full assumption of the rights of adult men and women.

Animals lower in the scale than those with backbones, have their lives regulated to a wonderful degree by what we have known as instincts. The comparative psychologist, studying the activities of animals as well as of people, tells us it is exceedingly difficult to say what instincts are and how they arise. For our purposes here we may look on them, however they come, as internal impulses leading the animal to behave as if he had inherited the habits of his parents, even if he has never seen them. He does not need to see any of his kind in order to know what to do under any given condition. What he does is usually quite appropriate to the occasion and helpful either to him or to his species as a whole. This makes the life of an insect, let us say, mechanical to an astonishing degree.

Some time ago one of my students brought to the laboratory an Ichneumon fly which, on her way to school, she had found boring into a maple tree. When she arrived she found no one in the laboratory with whom she could leave the specimen. She looked for chloroform, ether or a cyanide bottle with which to kill the creature but found none. Wanting to leave it, and seeing a sharp scalpel lying handy and perhaps remembering the farm method of dealing with a chicken, she cut off its head. What was her surprise to find the decapitated body flying away in dignified and straight flight, in the direction in which it was pointed. Soon it struck the wall, when it dropped

to the floor. Going to pick it up she found it, not huddled together as one expects to find a dead body, but standing quite erect and tense. She brought it to the table and cut off its abdomen. The thorax, to which both legs and wings are attached stood up as pertly as before, though it did not attempt to fly away. I came and was told the story. I gave the girl a box into which to put this standing thorax and told her to keep record of the length of time before it collapsed. The head and abdomen had been severed from the thorax at about eight o'clock in the morning. She examined it at frequent intervals up to four o'clock, in the afternoon when it was still well poised.

At seven, when she sat down by the evening lamp to study, it had sagged somewhat but was still standing. The warmth of the lamp seemed to tone it up and at ten, when she went to bed, it was standing well again. When she looked at it next morning it had collapsed and showed no signs of life.

There seems a sort of irresponsibility about an insect. No matter how often you disturb an ant's nest, the survivors at once go about repairing or removing the fragments of the nest and the young. They seem to know no despair.

A moth, attracted to an open gas flame, scorches itself and falls. It no sooner recovers from the shock than it approaches the flame again and again falls, worse scorched. This disastrous experience seems to teach it nothing and is repeated while there is power to fly.

Most insects, except bees and a very few others, never see their parents. But they go about mating and depositing their eggs in the situation suitable for their species as

thoroughly as if they had the teachings of a mother and the example and restraint of a social group.

On the other hand, the mammals come into the world utterly helpless. Dependent on the mother for food, they are most of them equally dependent on her for protection. They know little more than to "sit tight" in time of danger. This seems, in wild animals, almost as instinctive as the first cry, or the pursing of the lips to fit the nipple of the breast.

About all the psychologists except the behaviorists say there are many instincts affecting human life, but most of them are overlaid, concealed and often much modified, by intellectual effort.

With the growth of all mammals comes a most remarkable activity whose meaning again has only recently been recognized. The importance of play can scarcely be over estimated. In the beginning it consists only of apparently random movements of the larger joints of the limbs. This of course means that the nerve centers are gaining control of the muscles of these limbs. Then begins the characteristic play of the species.

Dogs mouth loose objects about them, gaining strength in their jaws which will enable them later to grasp their living prey and tear it down. To really understand this play on the part of a dog we must remember that by origin and at heart he is a wolf. The young wolf chews the sticks lying about the den, instead of the backs of books, the corner of wicker chairs and arctics, but the meaning is the same. A little later each will pick up some moderately heavy object and shake it vigorously. Two puppies will play with each other, each tries to catch the leg or the neck of the other. Neither harms the other,

because they do not bite hard in play, any more than boys, square boys, fight in football. But now and then a dog forgets himself and bites too hard and the play ends in a scrap—as is sometimes the case with his master.

The fondness of a cat for a ball is most natural. This toy can run off in any direction like a mouse. When you pounce on it you do not know which way it will start. So you pounce suddenly again, and again. This is the very best practice for a cat.

It was my good fortune one day to have the chance to play with a tiger kitten. The thing was big enough, its teeth sharp enough, and its jaws probably strong enough to cut my wrist in half. But it had no such disposition. When I trailed my handkerchief before it, it paddied at it just as would a house kitten. When I smacked it when it was bad, it cowered like a kitten. But if I kept that up, it would not take many days before the tables would have been turned.

I spent many hours one winter studying three chimpanzees. One day one of them had a ball, and I expected to see lots of fun. There was none at all. What plaything could be less suitable for an animal that lives in a tree? The ball was a flat failure as a chimpanzee's toy. A chain, a string, a screw, all were far better, particularly the chain.

All of this play function is just as true in the case of the human infant as of his wilder cousins.

His equipment at birth seems to be small. His first inarticulate cry which means "it is cold," but which serves to clear his breathing apparatus of mucus in his earliest reaction against the new world. His grasping lips next serve to help him to his only present nourishment. His

tendency to employ his hands in fondling his mother's breast while nursing, doubtless stimulates it to a freer secretion of his life giving fluid.

Then he lies back and crows—which certainly helps him find his voice, so marked a character of the human species. He kicks with his legs and struggles with his arms, learning how to make the machinery respond to his orders.

One of the most difficult tasks he has to learn is the very late human acquisition of standing erect without other support than the legs. Few animals besides man and his very nearest relatives ever do it, except under man's tuition. And the child must wait until the natural impulse comes. The mother imagines she teaches him to walk, but if he were left to himself he would learn it as well and nearly as soon, as he does by her assistance. Should illness keep him off his feet for any long period at the time the impulse arises, his mother will have the utmost difficulty in teaching him to walk, and the probability is there will always be a peculiarity in his gait that would not have been there had he learned under his first instinctive impulses.

Now however comes his training in the human acquisitions. These his parents themselves learned. He cannot inherit them. They must be passed to him by tradition. He makes inarticulate but quite expressive sounds. His cry of fright, his grasps of anger, his sobbing disappointment, his scream of pain, his cooing of content, are all instinctive and all easily understood. Beyond this however, he must be taught. He learns any language apparently equally well, at least in its rudiments. You will remember Dr. Johnson's naïve delight in the fact that in

France even the little children speak French. The child seems to learn two languages at the same time without any great difficulty talking perhaps Italian to his mother and English to his sister without much mixing of his words.

When the boy plays, he instinctively imitates the occupations of his father. He rides a stick horse, slashes with a stick sword, hunts with a stick gun. His earliest actions fit him for a wilder life than his present one. He fights—and in doing so bites, which only a very low grade man, a throw-back will do. And he lies; which does not throw back quite so far. His lies are usually bold and barefaced and as much bluff and bravado as deceiving. But it troubles his mother greatly, if she is unprepared first, and does not know how to face him down and teach him the ways, or at least the aims, of really modern civilization.

Meanwhile his sister is equally earnestly engaged in imitating her mother. Especially her doll needs her tender care. It must be put to sleep and wakened up. It must be dressed and undressed. It may be a scolding will suffice but probably a spanking now and then is needed. It is quite a later sophistication if the doll must be nursed at the breast. Usually it suffices to feed it from a plate or give it drink from a cup.

The girl child too must take stones and build at least the floor plan of a house. Doorways there will be, into the rooms. You will quite forfeit the child's esteem, and perhaps break down her willingness to continue the play, if on approaching her house you tread over a wall instead of entering a door.

A little later the child has her first needle and thread

and her first piece of real dough; mud has served before this.

Now soon will come the most bewildering change of all, to the child and to his parents as well. The awakening of the consciousness of sex is so marvelous and so hard to understand that a separate chapter will be kept for it.

With the larger mingling of the child in bigger groups come the team games. The tremendous significance of these is but little realized by most people. It is said the Battle of Waterloo was won on the Eton cricket field. Whether the boy shall grow into a man who can give and take, cooperate with his fellows for mutual good, deal honestly with his partners in business and still more with his customers, depends tremendously on how he has learned to play the game at school.

The coach who teaches his team to foul when the umpire is not looking, or when, even should the penalty be imposed, it is to the advantage of his side, is the man who in later life, will bootleg, or sell worthless stock and take the punishment, if caught, provided the returns are big enough to make it worth risking.

These gains of infancy are all comparatively easy to see. There are others not quite so simple. First of all let us consider the gain biologically. In this there are two great phases. We spoke in the earlier chapters of the fact that acquired characters are not transmitted through the germ plasm. The young must learn afresh what their fathers learned. The long period of helplessness, and the large brain of the human infant make it possible to transmit by tradition, by training, by education, the whole previous gain. It is this alone that makes civilization possible, and that makes its effects cumulative. Each genera-

tion adds its part to the previous store. There are two types of nature in mankind and each of us is likely to be prevailingly one or the other. The one clings tenaciously to the previously acquired store. He is the conservative in politics, the fundamentalist in religion, the classicist in education. The other sets his big store by the new, and is little attracted to the past. He is the radical in politics, the modernist in religion, the scientist in education. The world needs them both. Neither alone will serve. Where there is no vision the people perish; where there is little else, they die of hysteria.

A second result of the lengthened human infancy is the marvelous development of mother love, the most unselfish and the most utterly devoted affection the world knows. That a woman who has just undergone a long period during which she has carried beneath her heart a burden which is progressively a source of annoyance, then of discomfort, and finally of anguish, should at the first sharp cry of her child and at the first pressure of its tender lips upon her breast glow with devotion unutterable, is to me the crowning miracle of human life. A wonderful portion of the same miracle is the love it calls forth from those about the mother. The child soon comes to return this love with wonderful power. Wisely handled, this love will grow into a tender life-long devotion of the child to her mother.

Still more surprising is the softness this mother love has evoked from the father. Between mammals below man the impulse to mate bears no conscious relation to the offspring that may result from the union. Here there is little attraction the female has for the male between mating seasons. In man all this steps upon a much higher plane,

out of reflected glory of the mother love. Passion, in finely developed human beings, is still passion, but it is so overlaid with tenderness and consideration as to have quite transformed human mating at its best.

There is a religious side of the infancy problem as well. To a large section of the Christian Church the object of the most sincere and tender devotion is the mother and her child. It is the subject of much of the finest religious painting and poetry. Even in the rest of the church the Nativity is the time of the largest devotion and no other religious festival is so generally kept, or observed in so fine a spirit, as is Christmas.

But there is another side of the religious question. Jesus made it the most striking part of his teachings that God is our Father. This can be made to mean very much to the child whose early life is full of memories of a father who was all that a good father can be to his child, protector, guide, counselor, companion. When the child's impressionable years have been spent in the company of such a father the teachings of Jesus will bear full fruit in a noble conception of a God who is all of this, multiplied many fold.

On the other hand, what can be the result of teaching God as the Father to a son whose whole childhood has been embittered by the occasional incursions into the family circle of one whose coming is looked forward to with dread and whose retirement from the scene brings longed for relief?

Now for the practical side of the infancy problem. This is the period during which the child is preparing to make the decisions that must come to each one in life. There is only one way to learn to make wise decisions, and

that is by deciding and finding the result. That is the main lesson the father and mother must teach the child. It is not so much their function to make wise decisions for the growing boy and girl as to teach them to make such decisions for themselves. Hence it should be the constant policy of father and of mother to let children decide for themselves, under quiet and not too obvious leading, everything within the limit of their powers. In matters that are more or less indifferent, it were better the child determined less wisely than he did not determine at all.

As the years progress, and as rapidly as may well be, the extent of the matters that lie within the choice of the child should be widened. Twenty-one should not be the limit of the father's right to decide, it should be the limit of the necessity for anyone's deciding but the young man himself. Slowly the guidance of the father should grow less until at the reaching of majority the last vestige of authority and the last need of it should prove to have faded away.

Great decisions are always powerful in life only as they are the individual's own decision. Advice, counsel, may be valuable when wanted, and exasperating when not wanted. But decision, to have real value, must be one's own.

There are three great decisions in life which each must make for himself. Each of these will lack value if it is decided by others.

The first to appear is commonly the religious one. If the religious life of the parents is vital, if their connection with some branch of the church has been intimate and strengthening, it will be most natural that the child will find here also his own religious home. This tendency may

well be fostered but must not be forced. It must be the individual decision of the child himself. Furthermore, if, on later development and sincere determination, the boy decided that another religious home, or belief, or practice, is closer to his convictions, no obstacle should be put in the way of his making the change. Religion, to be vital, must be absolutely one's own.

Many a home and church are conservative in the extreme. In this form of experience the child grows up and to it he unconsciously conforms. Then he goes away to a broader environment. He comes in contact with those whose range of thinking covers wider ground. Here he finds that the type of religion he had must grow with his experience or utterly lose its vitality. If this young man is told by his parents and his pastor that he is losing his faith and that his religion is worthless, it is not unlikely that he will turn against all manifestation of religion. For a time his own inner life remains religious. Cut off however from the fellowship of others who think as he does, and with whom he can discuss his problems, religion will come to mean less and less in his life, to the serious detriment of his character and perhaps of his morality. The boy and girl must be free in their religious life.

The next great problem that needs wise determination, and on which much of the happiness of life depends, is the nature of the occupation by which the young man shall earn his living. If this be not congenial, and not clearly within the power of the individual, work becomes drudgery. When this is the case, it will ordinarily be ill done and comparatively unremunerative. The occupation one loves will never pall. The man may be tired by it, but not of it. His vacations are not for the purpose of re-

lieving him from work, but for the better fitting of him for his work. Here again the only lastingly happy determination is the one made by the worker himself.

The last great decision, before the great field of life is fairly occupied, is the mating. No one can do this well who does not do it for himself. Not all self made decisions are wise; some of them must be unmade. But there will be fewer mistakes when the matter is decided by the two most concerned than when others settle it. Above all, here no constraint should be exercised. Again counsel, information, discreetly tendered, may avail. But compulsion, even though it is hidden, is always a mistake.

Where the family is only a social convention, and where there is a tacit understanding that a discreet love life outside the family, if properly screened will be condoned, it may serve for parents to settle the marriage arrangements. But this is contrary to American ideals and almost equally to American customs. We show little tendency to yield to our parents the settlement of our love affairs. This is as it should be. Happiness can only be even approximated when the source from which our spiritual life is fed is appropriate to our type of mind; when the occupation at which the large share of our working hours is passed is congenial and for which we have ample training and capacity; and when there broods over life an atmosphere built up of love and trust between husband and wife and between parents and children. Add health to this, and wealth beyond mere competence has practically nothing to offer.

CHAPTER VIII

CHILDREN'S LOVE AFFAIRS

THE world in general is just beginning to take children seriously. A few psychologists, led chiefly by Dr. Stanley Hall, opened the way. They realized that the fuller understanding of the human mind would be much helped if we could watch its activities unfolding and its power developing. Since then, we have gained a respect for childhood and a willingness to take it seriously. We are beginning to realize that each stage of life has its own appropriate activities. Certain work is its natural demand, certain games are its appropriate recreation, certain fields of literature are its chosen domain, certain aspects of religion are its spiritual food. A child on whom is thrown too large a share of the work of the household becomes a pitiful drudge, but too little makes the child selfish and inconsiderate, especially of the household helpers. That games may be wisely graded to the age—the mental age—of the child is recognized in the amount of attention given to supervised play. Never before was there so much care taken to provide for the playtime activities of the young adolescent as to-day when scout troops are spread over the land. No other movement has been so wisely understood, so clearly recognized, so generously provided for the needs of the growing boy and

girl at that age when life is developing most rapidly and most bewilderingly.

The Boy Scout Movement has developed earlier and more thoroughly than the similar activity for the girl. The boy had previously been left far more to his own devices than the girl who grew up more closely guarded in the home. But guarding is not as necessary as guiding. Inhibiting wrong development is not as successful as fostering proper development. The results of the scout movement on the boy were so clearly splendid that we began to realize the girl might have her activities also. I think the Girl Scouts are a little too thoroughly patterned on the Boy Scouts, but this will help itself with experience, and meanwhile the movement is giving health and freedom to our girls at a time when they are still not too eager to escape restraint. Now freedom can be easily granted and kindly guided. If it is restrained until the dammed up demand gathers strength enough to burst its barriers it may become very difficult, if not impossible to handle—except in a reformatory. That institution usually gets its inmates too late.

Our librarians have been trained to realize that a big part of the duty of any library is to provide understandingly for the needs of children. A splendid literature is growing up adapted carefully to each stage of the child's development. Our school readers were once graded according to the ability of the reader to handle the words. How little the ideas were graded is evident by the old New England Primer with its

> "In Adam's fall
> We sin-ned all."

I memorized in the seventh grade passages such as Hamlet's,

> " 'Tis not alone my inky cloak, good Mother,"

and its still more incomprehensible

> "And windy suspirations of forced breath."

That these meant nothing to me is not due to lack of explanation on the part of the teacher. They were outside my domain, and no amount of explanation would have excited enough interest on my part to make the meaning hold, even if at the time I got it. When in later life I came across these passages in the play I recognized my old acquaintances, only to realize how superficially I had known them in the old days.

If during this time religious teaching is well adapted to the age of the child, a frame of mind which in time will become devout, and if need be consecrated, may naturally develop. But if "old folks religion" is loaded upon young shoulders there is little to wonder at should these shoulders dump the burden when free to do so.

So long as our Sunday Schools consider piety and life long devotion the only really necessary qualification in a Sunday School teacher—and this is true in quite too many schools—we may expect to see children when they get to be fifteen or sixteen ending their serious connection with the church. In far too many cases the final aim of the school is not the building of firm character but getting the children to join church. This they usually do. The extent to which the confirmation class of one

year drops out of all vital church activities within the next year tells how purely formal was the entire transaction. The child has now become "a church member," and it is supposed that this of itself means devotion to the cause. If the teaching had been as good as it is in the average public school, if the work had been as well graded to the needs of the children, if the presentation had been as skillfully done as a well trained public school teacher can instruct in the work for which she spent her years of preparation, the result would be much finer.

Adolescence is the natural time for the growth of religion. Never again will it be so easy to put idealism and cleanliness into life. Such teaching, however, means serious preparation, such administration means expense. But to-day many churches look eagerly to the money contributions the children can collect for the church, instead of furnishing equipment for the school.

There is no respect in which child life in the early day failed of appreciation more entirely than in the matter of its love affairs. We all knew that children fell in love. Most of us remembered very clearly little love affairs of our own early years. I remember there was one such for myself in a town we left when I was six years of age. At nine I was abjectly devoted to a cousin who spent months in our home and who was probably ten years older than I. I remember very clearly with what a sense of the desolateness of life I heard, at about eleven years of age, that she was not to wait for me to grow up, but was marrying a man of whom I had never heard. I was quite sure he could not be worthy of her. I think I subconsciously imagine to this day that he was not as fine as she, though he quite

probably was. Many people smile at such devotion, and some scold and shame the child. Those who really understand, rejoice, and, except to suggest a little restraint if the devotion becomes annoying to its object, let it finely alone.

What it is that, early in embryonic development determines the sex, is hard to tell. The x chomosome evidently is connected with it somehow. When the fertilized human egg cell has in it two x chromosomes, it will develop into a girl. When there is but one a boy is the result. Why, we do not yet know, just as we do not know how any chromosome affects development. But we know that it surely does. For the first eight weeks after fertilization, by which time the embryo is quite human in appearance though very small, there is no visible difference between the male and the female, even in the external organs of sex. Then these grow different for a few weeks, by which time the major differences are largely developed. It is not however before the eighth month has been reached that the male sex glands (testes) which have up to this time, occupied a position in the abdomen comparable to that of the female glands (ovaries), leave this position and slip, through an opening in the groin, into the sac which they are thereafter to occupy. The opening through which they passed often closes but insecurely, and in later life under serious pressure on the abdomen a loop of the intestine may force this weak spot open and produce a hernia.

We have spoken repeatedly of the endocrine glands, or glands of internal secretion, that pour into the blood chemical messengers known as hormones. These passing, in the blood stream all over the body stimulate distant

organs to unusual activity, or perhaps inhibit, forbid such activity. We have recently realized that the sex glands, both ovaries and testes, have in part this function of producing hormones. The gland is made of two entirely different sorts of tissue. One is the germ tissue itself, whose cells multiply into eggs or sperms. The other is the interstitial tissue as it is called, filling up the spaces between the germ tracts. This tissue produces the hormones, which poured into the blood induce the physical and psychological changes which make the differences between the sexes.

It is quite evident that there is a mild activity of these glands reasonably early, the effect being largely psychological. At twelve or fourteen, earlier on the average in the girl and later in the boy, the glands become thoroughly active, and the physical, physiological and psychological changes appear. Physically, to the world at large the change in the boy's voice is the most apparent feature. Then his self-consciousness and consequent extreme awkwardness follow. Soon a down appears on his lip, which he shaves almost before anyone else notices it. A similar coating appears in the arm pits and the groin. Now the boy begins to have his first real sense of the restraint of the home. This is the time, if the tension is too strong and he is not wisely handled, that he runs away. Should this occur and he be found and returned, an entirely new treatment must be given him. If there is not, he either becomes broken and spiritless, perhaps for the rest of his life, or he runs away again. His previous experience has taught him better the difficulties. This time he meets them better, and may have finally parted from his home. This too,

when most he needs sympathetic, kindly, inspiring companionship, especially that of his father.

In similar fashion, as the ovaries begin to ripen, an egg and the first gentle mestruation appears. The interstitial cells also send their hormones coursing through the body in the blood stream. The amount of these substances is astonishingly small. Their transforming power is marvelous. The girl has slender lines which of late it has been fashionable amongst our young people, to want to retain into young womanhood. They give what is sillily termed a boyish figure. It is far from this; it is simply the infantile stage of body development. The entire figure now tends to become more plump, putting down a layer of fat just beneath the skin, obliterating the outline of the muscles and giving the softness of line which is a woman's glory. The hips gain a disproportional amount of this fat, doubtless padding for safety sake the future home of her children. The breasts appear in three distinct stages. From about fourteen to sixteen they are simple cones scarcely more than two inches across the bottom. At about seventeen, for a year and a half to two years, the cones are lifted up and stand out of the rounding mounds beneath them. By about eighteen the cone is swallowed up in the rounding portion and the mature breast is fully formed. Hair is strangely proportioned between the boy and the girl. The general body hair is ordinarily much more luxuriant in the man, as is that on the face. While the woman has much less body hair, that on the head, except on the face, grows much longer than it does on the male. This is not simply because the boy has his hair cut. Occasional men—the old "Indian doctors" for instance who

sold patent medicines from open wagons in the public squares—let their hair grow uncut, but it rarely reaches farther than their shoulders in the white race.

These bodily changes have been described much beyond the stage of the parallel psychological phases which we want now to consider.

The children's love affairs of which I speak are generally considered at least foolish when not obvious enough to be annoying. They are usually frowned upon by parents, in the notion that these youngsters are beginning too early what propriety demands should be left to later life. "You are too young to fall in love," is the common dictum of parents. Meanwhile their reason for falling in love is chiefly that nature has turned on the stimulus.

The wise part for the parent to play is to try to understand these young people. Particularly they must see that the little love affair proceeds naturally on its own gentle level, and is not forced by imitation of the older love affairs of those about them. As long as their activities are those of children there is everything to be desired in this fondness for the individual person of the opposite sex which sets him apart from his fellows. Now is the time when the child willingly learns to be altruistic. Now selfishness gives way not to a conventional sharing but to a real disposition to share what one has with another. Here the first lessons in that politeness, which is the form of altruism which civilization has found helpful, may be easily inculcated because the individual is internally prompted to feelings that lead this way. Tuition merely decides the form into which the impulse shall work.

I think whatever of real heartfelt chivalry the boy is ever to have, has its foundation at this age. Years ago

"kissing games" were very common and were perhaps not so seriously harmful as many anxious parents seemed to think. This was a too early introduction into the childish years of the habits natural to later life. But to have all demonstration of affection strictly tabooed, as if in young people it had the same dangers which experience has shown it often holds for older folks, is to make a mistake.

Society decides for itself in each age, the extent to which such demonstrations are "nice." But there is no doubt in my mind that it is quite possible to teach young people to be so "proper" as to bring about a constant repression of the sex emotions, such as is liable to work a double harm. In the first place it produces a repression, on the part of the girl, whose harm we are just beginning to learn from Freud and his disciples. It was the chief agent in the making of a pitiful character who fortunately is beginning to disappear from American life, the old maid. She was a striking example of the baleful effects of a thwarted sex life. She was a nuisance to herself and to all about her.

The other harmful side lies in the fact that the boy is not so willing to repress his demonstrations. He becomes imbued with the idea and with the experience that "nice" girls will feel insulted at any familiarity. Then he is almost certain to find near at hand, and often not in his own set, a girl who is not so particular. The fact that he has been driven from his own group for his enjoyment of the small intimacies which quite satisfy him at this time has taught him to conceal his actions. It has removed this side of his life from the frank

living of it in the sight of his parents and of his companions.

If now he falls into a wrong set the lessons will be learned with precocious rapidity and sometimes with disastrous results. Then his people helplessly talk about his having gotten into "bad company." Any boy or girl, who has a fine free life—and I do not mean by this a life of unrestrained license—will by the very nature of human psychology find his own set most congenial.

We must learn then to see our young folks live naturally together. We must see that it is quite human for them to have these little fondnesses which are the lessons which will finally teach them the great fondnesses. It is when these early exercisings of the sex impulses have a natural development, proportioned to their age, and showing its preference chiefly in small companionship, that the foundation is laid for a fine development of a later love life. When these earlier devotions are frowned on and the boy and girl are led to inhibit them, there comes a time when, urged by the growth of strong passions, the barriers are broken down completely and restraint thrown entirely aside. Tenderness and devotion should have been learned before passion.

Our youngsters recently took this matter into their own hands and the openness and the frequency of "necking" shocked all older people. The revolt was natural and, in spite of its foolish excesses, not entirely unwholesome. Our young people have already realized, to a very large extent, that there is little "kick" in demonstations of affection that go beyond the affection itself. They have learned that endearments with those who are not dear yield little of enjoyment, and that there is too little left for

the time when there is real devotion to express. The excesses of this movement are rapidly passing away. But it is the significant thing that it is their own experience and their own determination on the part of the young folks that is limiting it and not the objections of parents. Parents lost their power by asking too much.

In closing I want to speak of the danger of treating with ridicule these childish affairs. A friend quite past middle life told me in an hour of confidence, of his own sad mistake, realized only when it was too late. He began to notice that every now and then his daughter started a friendship with a young man. The intimacy seemed to proceed quite naturally for a little while and then faded out. There seemed no evident incompatibility. The girl was a lovely girl, her friends were pleasant fellows. He began to suspect his daughter of a natural coldness that repelled all advances on the part of the young men. One day he quietly and most sympathetically tried to question her. To his entire surprise she burst out crying, saying "Don't you know what is the trouble?" He certainly did not and besought her to tell him. "Do you remember that you told me I was boy crazy?" And his mind ran back to a time when, years before, in a country home the boys of the party, then not more than ten years of age, had started to go somewhere and did not want to be bothered with girls. She had not realized their wish and ran to join them, while they tried to escape her. Her father had called her back and had said to her "You are getting boy crazy." The sensitive nine year old child, turned in on herself, learned a new and pitiful lesson of self-repression, where there was neither virtue nor value in restraint.

Said he, "I dropped on my knees before my daughter and with tears in my eyes begged her pardon. But it was too late. In a minute she was calm, and never referred to it again. Repression was again at work. But I fear I have given her life a somber color it need never have had, by my thoughtless and tactless expression."

CHAPTER IX

THE AGE OF ROMANCE

By the time the boy and girl are from sixteen to eighteen, more likely to be earlier in the girl than in the boy, and earlier in the city than in the country, we come to the Age of Romance. This is the time when character gets its most important set. This is the time when personal religion is most likely to lay its hold on our young folks. If it does not a later "conversion" is apt to be stormy or ineffectual, and sometimes both. At this time poetry gets its real hold, if it ever does. At this age almost anyone tries to write a little poetry. Now idealism appeals to boy or girl. The experiences of life have thus far been enjoyable to most of them, even amongst these whose means are so small that later there will be discouragement and discontent. Now if ever, the young men see visions, and the maidens dream dreams. Now of all times these young people need sympathy, need kindness, need to be allowed to develop their own individuality, profiting by good example but not constrained by unacknowledged authority. When older people say this is the happiest time of life, it almost invariably means that their own lives did not develop as well as they might have. Their visions clouded, their dreams disappeared. They let themselves sink into "practical" life, foregoing their earlier aims.

But when this time of life is lived finely, it is the foundation for all that is best and noblest in later life. Here as nowhere else can the trends be laid down that make for a long life, in which ideals are never quite lost sight of and often come to conscious activity. Here the literary tastes are apt to be laid that make the great literature of the past a constant pleasure; that form a taste for that in modern literature which is strengthening or helpful or leads to the enjoyment of the gracious and lovely in life, and looks with regret even when it needs to know the less seemly aspects.

With the flooding of the blood stream with the hormones from the rapidly developing sex glands comes a whole new view of life. Boy and girl had played with each other freely and quite unconsciously. Then began a realization that there was a contrast. The boy finds there is the touch of quite a different pleasure in tussling with the girl from that which comes from a similar encounter with the boy. He must beat the boy at all hazards, and does not hesitate at any roughness necessary for the purpose. When he tussles with the girl he must beat her too, only he must prolong the fight, must just beat her in the end, and must not hurt her in the doing of it.

Meanwhile she rejoices in his strength. She exerts all her own, but does not really want to beat him. She likes him to tell her how strong she is, nearly as strong as he. But the tussle of girl with girl has little pleasure left.

Soon comes to both, and often quite suddenly in the midst of the tussle, a sense of the unseemliness of the process. The struggle ceases and is never resumed.

It often happens that about this time the contrast between playing with another boy and playing with a girl

assumes so much difference as to be quite disconcerting. For a time the boy avoids the girl—does not want her with him when he goes out for sport. It does not take long for this stage to pass. Shamefacedly at first, but gradually with more and more assurance, the boy and the girl find each other the best of company and frankly seek each other out.

This marks the real beginning of the age of romance. If now all goes well, the end may come only with life.

There must first of all be no ridicule. The budding love is as sacred as anything in life. The fact that it often lasts but a little while is rather in its favor. It means a growing appreciation of a larger variety of character. But while it lasts it should be treated finely. It does not think of marriage. In this early stage companionship, slowly growing more intimate, is quite enough to satisfy.

It may have been natural for our animal ancestors to experiment on the near road to physical gratification but men have gone beyond that. The long ages since he was beastly have borne their fruit. The natural impulse at this time is to reverence. The boy makes his tender advances but he has no thought of the later sexual union. The girl is now modest. She has every impulse to curb too rapid advances in familiarity. And this is not because she feels them wrong, she only feels them too early. She must not lightly surrender her personality. In time, with such fondness and esteem as makes her feel herself quite safe in his hands she yields herself more liberally to her lover. And yet, I think I am safe in saying, the Christian world has long enough reverenced the marriage relation, and looked with disesteem on sexual intimacy out of marriage, that it is entirely natural for these young lovers to

grow quite intimate in their fondness without the desire for the closer union becoming at all difficult of restraint. This is, however true only when they may look forward with reasonable hope to a marriage not too far ahead. By the time the boy is twenty-two and the girl is eighteen or twenty, either of them is as physically capable of marriage and of having children as they ever will be. It would now be quite natural for these to be married. Unfortunately for this result our civilization is so complex, that it is very difficult for a young man to get on well enough in life to be able to support a wife before he is twenty-five or thirty. This is a new situation in the world's affairs. If all is to be well, we must face it. One of two solutions, both entirely satisfactory, I think, are before us.

The first is that the parents must look upon such an early marriage as desirable and must be willing to help the young folks along by some sort of subsidy. If the father can take the son, or son-in-law into business with him the way is most easily open. The young folks must ask only modest beginnings, but with this they will easily content themselves if they love each other and have been nicely trained at home. Few things can militate more harshly against a young girl's happiness than to have cultivated and fixed in herself such luxurious tastes as no man can satisfy before he has become well established in business.

On the other hand, there is no other time in life when happiness is so absolutely independent of luxury for its existence. I am quite convinced that it is the parents who demand too much of the young man far oftener than it is the girl herself. Modest income in early married life is

easily bearable, because there is then every confidence that it is only temporary.

There is another solution. We are just beginning to look on it as a permissible one. I am confident it will gain in popularity as time goes on. The young folks may both continue to work, after marriage, and to keep it up until the husband's earnings grow to such an extent as no longer to make it desirable that his wife should earn a portion of the income by working outside the house. It may well be that for some time she will still work about as much inside the home as she did outside. This should mean not a little lessening of the joint expenditure, to help to meet the lessened income.

The one most natural objection is that a child may be expected at any time to break down the whole scheme. The answer to that of course is that birth control is not only becoming better understood and more widely practiced, but also is coming to be respected by a larger number of people. There is no reason why a child should unexpectedly appear. I am personally quite of the opinion that young people who have not been instructed in birth control at the proper time and by some proper person, who has definite and satisfactory knowledge of the subject, are unprepared for marriage.

To delay the wedding until the ordinary young man is prepared to provide income enough for comfortable living and for the support of an increasing family is too serious a denial. I am convinced it is dangerous either to morality or to good, healthy development.

I quite agree with those physiologists who say that long continued entire continence is not incompatible with good health. But I am equally strong in my conviction this

is only true under the most favorable conditions. I am sure those conditions do not obtain under the circumstances of a lengthened engagement to be married and far less, in marriage itself. Let us help our children to happiness by every effort in our power. Let us consider that a civilization that postpones marriage, puts on the parents the obligation of assisting young married couples.

We have recently had recommended by one of the most earnest workers in the field of morality amongst the young, that a special form of union, which he has made familiar under the name of "companionate marriage" be instituted for their benefit. He suggests that such an arrangement be recognized as honorable and valid, but that it be easily terminable by mutual consent so long as there be no children. I quite freely confess that my own experience is far more limited, than is Judge Lindsey's. He however has been brought professionally into contact with the seamy side of life. My own contact has been with thousands of young men and women preparing to teach. They are naturally a rather picked group. They are far from "plaster saints." They are sweetly and beautifully human. They make occasional mistakes, sometimes very serious ones. But on the whole, they are so fine minded, so clear eyed, they are looking so frankly on life, so much more frankly than did their mothers, that my plans are for them and their kind.

Even when I read Judge Lindsey's cases of missteps in the families of preachers I am convinced that my people represent more accurately the great mass of the American people than do those who get before the Judge, either unwillingly because they have come in conflict with the law, or willingly because they find themselves running counter

to the conventions of society. The point in which I hesitate to go along with Judge Lindsey is in asking that divorce be made easy under these conditions. I should fear its leading to lightly and hastily made marriages, with the knowledge there would be no trouble in the unmaking. Lifelong monogamy has been so slow a conquest of evolving man, and is even yet so precarious in its hold on so many, that for civilization to draw back would be to sacrifice much that has been won. I trust society will always give its sanction to lifelong monogamy not only as the ideal but as the natural accomplishment of fine people. By this term I do not mean people of wealth or of education, or of culture, I mean it to apply quite as well to people who are of unexalted social standing, of moderate means and of modest education. There are many more fine people in our population than there are of those who are wealthy, or socially prominent or scholarly.

Let us then hold up marriage, the union of one man and one woman, who not only formally promise, but who have waited long enough to know each other well, and have thought of the matter seriously enough to both hope and expect that the union shall endure while both live, unless one or the other should become utterly unworthy of this most intimate companionship with the other. This is the goal to which civilization is tending, this is the goal it will ultimately attain. To abate this ideal is to surrender a part of the long uplift, and to sink back into a valley from which the ascent must again be made. A high ideal is always difficult of attainment, I confess; but not so difficult but that I confidently believe the majority of American families attain it so nearly, taking our people as a whole,

that the slips are almost negligible in number and amply atoned for and forgiven between the man and his wife.

Let us not let down the ideals of married life. Let us consciously and heartily help our young folks to build up high aims.

It may have been "mid-Victorian" to write novels all of which ended in marriage after many trials and which took it for granted that the rest of life is happy. I venture to believe there is a larger proportion of the novels so written that will remain a permanent part of English literature than of the stories of today, so many of which begin with marriage which is soon dishonored. There may be literary quality displayed in the portrayal of such failures, but I believe all great literature helps to lift the ideals and stimulate the efforts to higher life of the people of the time in which it is written.

Is it to be wondered at that our young folks get their conceptions of marriage builded on Jiggs and Maggie or on Andy and Min, if they rarely hear a fine word of testimony from those who have lived lives perhaps not so adventurous and variegated, but much happier and of more value to the community.

We should do everything we can to foster romance in our young people. When the young man deeply and sincerely loves a young woman, it is not only natural, it is desirable, it is blessed, that he believes her to stand out like a queen amongst women. When he tells her of this, no good woman is unduly elated. She is filled with an earnest desire, not to conceal from him his mistake, but to see to it, God helping her, that she does everything within her power to make herself all he believes her to be. Any decent young man, who finds that a lovely woman thinks

him finer, and more honorable than his fellows, will have the strongest stimulus life can give, to make himself, God helping him, all she believes him to be.

It is cheap to say they will find out after a while that each was mistaken. Where romance has done its natural work this discovery is not at all what the cynical expect. With the growing intimacy of married life both have found so much in the other of which they never knew, that gradually these lovers have both modified their ideals unconsciously until they fit the new conditions. That married man is indeed poor who does not think, that while there may be women who are more beautiful, or more stylish or more energetic than his wife, that on the whole no other woman could possibly have made him quite so happy. Such is the power of a noble love—and much love is very noble even amongst inconspicuous people.

I stood by the side door of my laboratory one day with one of my pupils, a boy of perhaps seventeen. It was during the change of classes when students were passing from one building to another. Along the walk in front of us came a girl. Fine, she was, as were very many of her companions. I had seen little to mark her out beyond the rest. The boy, nodding a greeting to her, turned to me and said, "That girl always reminds me of a fine old Roman matron." It would have been easy to laugh at him—and it would have been cheap fun indeed. The boy knew little, I imagine, about Roman matrons. But some teacher, probably of history or of literature, had said something, perhaps about Cornelia and her jewels, which had given the boy the idea that a Roman matron was as fine a woman as the world ever knew. If that had been all, it would of itself have done him good. But it was not all.

He had sensed this girl as all that was needed to fill that ideal in his mind. The girl, even though she never knew his attitude, was blessing his life. She was making it easier for him to keep himself fine and clean and strong.

Our girls too are building up about our young men equally honorable and worthy pictures. Nothing in this line has ever impressed me more than to watch the conduct of a good football game. There stands a double line of young men in the center of a stadium filled chiefly with other young men and with young women. The rest are those who are still trying to keep touch with youth. There is nothing in the clothing of these players to add to their attractiveness. Their suits are ill fitting and dirty and are padded out of all shape. Their heads are covered with leather helmets, and perhaps the face is disfigured by a rubber nose guard.

The line snaps to attention. The captain calls a series of figures. Suddenly the ball is in play. It has been thrown to a young fellow who leaned keenly forward, just back of the line. He catches it and takes it under his arm. He crashes into an opening made for him in the line by his comrades, and breaks through the enemy's line. His opponents try to bar his passage with tactics that might easily do him bodily harm, but this never brings to his mind a moment's hesitation. Fearless of consequences to himself, he pushes on until an opposing tackle throws him down. As his opponents pile on him he pushes forward until absolutely fastened down. Then he pushes the ball forward the last possible inch. The whistle of the referee commands the distentangling of the pile and the young man rises dirty, and bleeding, but he has made the gain for his side. From one whole side of the stadium comes a

mighty roar, and from the other side even an involuntary tribute of admiration for the splendid play. At that minute there is not a girl in that vast crowd who would not be proud to walk down the field with that dirty, bleeding, quivering boy. And she is right. He is strong—yes. He is skillful—yes. But best of all, he can forget himself and his own safety and put first the success of his team, the honor of his college.

God bless our young men, and keep them strong and fine and clean to win and match our fine, clean, strong, young women. Let us honor them, and help them by example and, when the good time comes, by the word of testimony, and if necessary by substantial assistance to go starry eyed, hand in hand, into the battle of life. To such, the age of romance will end only with life. Achievement will always hearten, mistakes will not too long dismay. But romance, its face changing as the years go by, will never leave them. The sunset will find them, with gray heads but young hearts, facing calmly, and hand in hand, the twilight.

CHAPTER X

WHAT SHALL WE TELL OUR CHILDREN?

I CAN imagine some of my readers, especially amongst the older ones, exclaiming with surprise on reading the heading of this chapter. They have themselves shrunk momentarily now and then from the plainness of speech they have met in this book. But talk about it to children? Why sully their minds with such knowledge? Let them grow up in innocence and purity.

In the first place, I am sure parents have been very remiss indeed in their duty to their children, and in all likelihood to themselves if they feel that this knowledge sullies anyone if it is true knowledge and is openly and frankly obtained. But if the whole subject has never been discussed by them, and if their children's questions have been waved aside with the statement "It is not nice to talk about such things," then the children will go elsewhere for their information. Thus the habit of keeping the whole sex side of life under cover as if it were shameful will have been started.

The present generation is absolutely right in at least one respect. Its members have removed the taboo on the discussions of sex. They have perhaps run too far on the other side, but that is only natural after the long suppression. They talk as if they knew all about it, even when they really know but little that is worth knowing. It is our

part to see that the knowledge they have is worth while, and that they have it soon enough to prevent ignorant mistakes.

This is far from meaning that they should be flooded with sex knowledge. This should take its natural place as a part of all scientific knowledge. High school biology should offer a late opportunity, after which there should be no hesitation about talk personally and plainly to any boy or girl. This is particularly true with any who show by their bearing that the new impulse to friendliness to the other sex is working in their veins.

Even if it were desirable that children should grow up in a state which we are prone to call innocent and pure, it is practically impossible. I think most of us older people, if we run back in our minds to hunt for the earliest consciousness of this subject and how it was gained, will find it runs back nearly as far as memory goes. My first recollected lesson is perhaps the nastiest and came from a girl who could not have been more than twelve years old. She was called in occasionally to care for me when my mother wanted to go out for the afternoon; and this was in a town we left when I was six years old. It is folly to say a child of that age can get nothing from such lessons. I must have gained some impression, or the memory of it would not have persisted for sixty-odd years. I can remember later chance lessons, chiefly from servants in the home. The pitiful circumstance is, I never had a word of counsel, of information or of warning from parent, teacher or friend before I was well established in life, and had been married. It is certainly more by good fortune and by favorable surroundings than by any teaching I have had that I did not make shipwreck of early life. So entirely

repressed was the subject in my early days that the effect is still upon me. While I have by conviction of the necessity and of the value of such knowledge come to speak clearly of these things to my students, I still must remind myself of the need. It is not yet natural to me to speak even as freely as I have spoken in these pages. But I have rarely spoken clearly to class or to individual without feeling the assurance that the knowledge was welcome and in some cases came in time to immediately help in a favorable determination to stand for higher ideals. The impulses are in the blood, and they make themselves felt in every healthy boy and girl. There are abundant influences about, in literature and in companionships, to make it easy to dally along a dangerous path. Shall not we, who know the beauties of the upper road, help our young folks to choose it?

An incident in my own family led me to my first genuine conviction of the wisdom of this frankness. My children, a boy of about eleven and a girl of about nine, had as a pet a delightful little fox terrier whom they called Trix.

My daughter had a room that was quite simply furnished because later we would want to dress it according to her taste, as that matured. Meanwhile a packing box was covered with a flowered chintz and had a valence at the front. Surmounted by a curtained mirror, this served her for a dressing table. The box itself was lined with muslin and was used to hold her bed linen and towels.

One day my wife came to me saying, "We will have to get rid of Trix." When I asked why, her reply was that the dog was about to have pups. "Why not let her have them here," I asked. "Do you want the children to know about it?" asked she.

On consideration we agreed that it would be just the very best time and way for the whole matter to come to their attention, and we decided to keep the dog at home.

One day my daughter came to me with the story, "Trixie is tearing the lining out of my dressing case." I told her, "Trixie is going to have babies, and she is getting a bed ready for them. Take the linen out of the case and let her do what she wants with the box."

Sometime later, I was wakened in the early dawn by the hand of my little daughter, who was standing by my bed. "Papa, Trixie has a baby!" "Oh, is not that splendid! But it is too cold, dear, to stand around; go back to bed and we'll see it in the morning."

She was a very biddable child and obediently she went back to bed. I had hardly fallen asleep when she was back again. "Papa, Trixie has two more babies." "Oh! is not that fine? Two more? But run to bed, dear, and don't catch cold." Away she pattered, but after a while she came once more. "Papa, Trixie has four babies now." This proved the last trip. But I think Trixie could hardly have been more happy over her puppies than was her mistress. Perhaps the character of that lesson was never lost. In recent years the same girl has been both successful and happy in breeding and rearing collie dogs of the finest strains.

After a little, it was agreed upon between my wife and myself that she would take the girl and I the boy, at some good opportunity, and explain how the puppies came, and to extend the story to themselves.

Finding an early chance, I took my boy to my laboratory, where with models and diagrams I explained to him very fully the whole story of the dogs. One of the points

that struck the children was the short piece of dry navel string still attached to each puppy. I reminded the boy of this and then recalled the same mark on his own abdomen, and told him that was the scar of the attachment between him and his mother. I saw his face grow thoughtful when it had been only curious before, and I believed he was passing comfortably from the dog to the human story.

That night my wife asked me whether I had not talked to the boy that day. When I told her I had, she replied, "I thought so. When he kissed me good night he held me as if I meant more to him than I ever had before." Then I knew we had done wisely in having the puppies at home.

When instruction to children shall begin depends much on circumstances. At any age at which there is curiosity, there should certainly be information to meet the need. With increasing age the explanation should be fuller and more definite. When the boy or girl enters high school there is no longer any doubt as to the need. In almost any such institution there will come now and then a combination of circumstances that will send a wave of sex activity over the school. The less the pupils know from clean sources about such matters the more likely such a wave is to gain impetus and to go far. Usually the teachers get an idea of what is going on and the wave is checked before most of the pupils know anything about it. Occasionally a really bad outbreak comes and startles everybody concerned. In any event, there are always a few with vulgar minds and distorted information who are ready to spread their vulgarity and their misinformation. Anyone who has been decently trained and properly informed sees at

once the nastiness of the spirit and the crudity of the knowledge and laughs at the informer.

In conveying any knowledge of this subject at any age, if figurative language is used care should be taken that the figures do not lead to such mistaken impressions as make it necessary to unlearn later all that has been gotten. Nothing could be more foolish than to tell young children that the stork brings the babies when there is no stork ever comes into their experience. It is well enough for grown people who dislike simple language on such matters to refer to a coming delivery as the arrival of the stork. But with children it is all wrong. Later the child, becoming aware of the evasion, will go elsewhere for his knowledge, and keep secret what he gets.

Still less true, and much less romantic, is it to have the baby come in the doctor's black bag. When sister wants to know where the little baby came from, I think the most satisfactory answer is "God gave him to me." When that needs expansion it becomes "God put him beneath my heart, so love would be ready for him when he came." A little later it may grow into "God got Papa to put some of his qualities beneath my heart, so baby would be his as well as mine."

When the child is old enough to wonder how papa did this, the time has come for the whole story. It will be much better if the way is opened by the understanding of the flower, as explained in an earlier chapter of this book. If an experience with mating animals has come under the notice of the children, and young puppies or calves, or colts or lambs have been their companions, the way is very easy.

There is a sexual crisis in the life of both girl and boy

that should by all means have early and natural explanation, or it will get its own interpretation that will be far from reassuring.

When the girl is about ready for her own first menstruation the mother should lead her to expect it and to understand that God is beginning to get her ready to be a mother sometime in the future. She should be told that this power cannot come all at once, but must ripen through young womanhood, so that when marriage comes, and parents and a home are ready for the child, it may come. Particularly, do not teach the girl to think of her flow as unnatural, annoying or even as being an illness. Do not tell her she is "unwell." Teach her of the fineness of the process, and that, because of what it is at some time to mean, we speak of it little except to those very near us. But make it a cause for a sense of growing power instead of a dread. It would be beautiful if the child could be taught with each return of the flow to offer to God a prayer of gratitude for the growing power, and of petition to help her make herself ready to be a fine girl and in time a noble wife and mother.

The "conspiracy of silence" in sex question has been so extreme that the matter of which I now speak may come as a surprise even to mature mothers of boys who have grown up. There comes to the boy an equally critical period, though not so regular, nor so predictable in time. When the sex glands are maturing, the fluid produced, containing the sperm cells, is partly reabsorbed and partly passed away with the discharge of the urine. But it often accumulates, in any healthy boy until there is a considerable amount in the storage vessels. Then, during sleep, there will come a dream, involving usually

some slight experience, not necessarily sensual, especially in boys who have not been over stimulated in sex matters. With the dream will come a discharge of this fluid, wakening the boy. This should be anticipated by the boy's father, and robbed of any sense that the occurrence is unnatural. It will be nature's relief of continence in later life, if circumstances require continence.

The boy should be taught that this is the natural beginning of God's preparation of him for later marriage and the begetting of children. As in the case of the girl, it would be fine if he could be made to feel the impulse at such a time to thank God for his growing power of manhood, and to pray for help to make himself worthy of the time when he will be a noble husband and father.

I am particularly anxious to have parents realize what I have just said because of a circular shown me some years ago by the Principal of a high school. The leaflet had been sent by mail to one of his pupils who was wise enough to bring it to him.

The discharge I have mentioned was described luridly and called "wasting manhood." Then the boy was told that the discharge was a symptom of disease. He was directed to go to a drug store and buy a crystal of nitrate of silver. This he was to dissolve in water and add to a portion of his own urine. If there was a white cloudiness produced, it was a sign that he had the disease, and needed their medicine. As a matter of fact the test is the accepted test for common salt, which is always very abundant in urine, and the cloudiness would always appear whenever the test was made.

I think most parents have come to believe that the teaching of sex questions is necessary. There are two difficul-

ties they face. They have never come near enough to their children to have entirely won their confidence. This is a sad state of affairs, and the fault always lies on the side of the parents. Mother should be and naturally is, if she begins early enough, her daughter's refuge in time of uncertainty. Equally the father should be the natural source of inspiration and of training for his growing boy. It is a boy's tendency to worship his father (and love his mother) if that father is reasonably worthy of the boy's esteem, and keeps himself in friendly touch with the boy.

The second difficulty is a lack of knowledge. The next best person, to the parents, I think, is a wise teacher. But this is not so good, earlier than sixteen at least, as if the father or mother can make the natural contact. Teachers are now usually trained for their work, and I cannot think them well trained if this subject has not been a distinct part of their education in biology, physiology, and hygiene.

But should the parents find themselves lacking either in confidence or in knowledge, then they should put into the hands of their children some recently written book that makes no mystery and does not speak in bated breath but cleanly, frankly, and scientifically tells its story. There are not a few such books, adapted to various ages of young folks.

But during it all, see that our boys and girls have abundant opportunity to meet each other in the athletic field, on the hillside, and by the river, and lake. Let them, in groups of some size, see each other constantly. Encourage them when they go "by twos" to go in the sight of all men. Teach them to prize their own individuality and not lightly to yield it to another. Help them to come to the

conclusion, which many of them are coming to by themselves, that indiscriminate petting is cheap and silly, because it is going through the motions of endearment when the people are not dear to each other, and that it leaves them after a while with no appropriate means to express a real and abiding affection.

CHAPTER XI

THE BACHELOR AND THE SPINSTER

There can be no possible question, the ideal, the natural, the most desirable, and the only completely satisfactory solution of the sex problem is marriage. This does not mean that marriage is often all of these. But nothing can be all of these except marriage.

Every healthy human being has a whole set of organs, which he shares with all the animal world but the lowest, and which serves in all but these very low animals as the only possible means for the continuance of the species. Hence the function of these organs is tremendously important, and nature is most imperious in her demands for their activity. To close ones eyes to this fact is simply to glory in ignorance and to court disaster.

It is equally foolish not to realize that the sex demand is far older than the human species, while marriage is a new institution. Particularly marriage involving religious ceremonies and having legal status is very recent in comparison. Hence it is the latter that can most easily yield. So it comes to pass that modern civilization built as it is upon the family, in every effort made to keep our social life fine, demands that mating and weddings should go together; and they do so whenever society can have her way.

Those whose regard for convention is small, and on

whom religion lays but a feeble grasp are not unlikely to step aside. This is particularly true of those whose own morality does not lead them to realize how absolutely modern society, with hosts of its laws of social relation, of legitimacy of children and of property inheritance, is based on an unquestioned monogamy. These not only feel the urge, but repeatedly wander from the path which convention, religion and morality mark out as the path of virtue. In our age and civilization, so absolutely is this true that when we speak not of virtues, but of virtue, especially in woman. we mean chastity. If a woman is known to have all the virtues except virtue, she may expect the cold shoulder from her acquaintances who are either conventional, religious, or moral.

It is a patent fact that very much of the present day fiction has its interest hanging on such infractions of the conventions. The ordinary magazine stand has a considerable share of its periodicals which depend on this dereliction for almost their entire interest. This prevalence of infidelity as the topic in much of our story writing and the frankness with which the relationships between men and women are discussed in the newspapers, the best magazines, in serious literature and from the public platform, has led most people to believe that the present generation is far less chaste than its predecessors of fifty years ago. I quite doubt this.

Education is far more common than it was. The reading habit has marvelously extended within the last fifteen years. The vulgar story, which flourished in the smoker of the pullman, in the lobby of the hotel, back of the barn and in the back room of the tobacco shop, has about disappeared. Men have grown ashamed of the habit; but

something of the taste remains. This is satisfied with the cheap literature of the character I have mentioned.

Doubtless some kinds of women, not socially disreputable, regaled each other with the same sort of stories, probably a little more elegant in diction. At least one sees on train and trolley car these magazines in the hands of women and girls who look, to a man who lives and respects women, as if they were quite beyond such tastes.

Then too, we are becoming urban instead of country dwellers. In the large city all the social forces are less binding in matters which do not lie before the open eyes of men, than they are in the country. Men and woman may dress more to suit their fellows, and may live, in the great public places, quite more conventionally in the city than they do in the country. But in the country everybody knows everybody else. Improper living is never long concealed, and the power of the opinion of one's fellows is far more keenly felt. In the city it is quite possible to evade the notice of those whose opinions run counter to our wishes. Our untoward conduct is likely to be known only to others who are doing just the same, and hence whose disapproval is unlikely or is disregarded.

I quite doubt whether there is more irregular living than there was when I was a boy, fifty years ago. What there is receives franker acknowledgment, but I really believe irregular relations are more casual, and prostitution less common than then. My knowledge of metropolitan cities was small in those days and my personal knowledge of those cities now lacks intimacy with that side of life, or with the persons who live it. But my knowledge of the life of the sort of cities, smaller than the ten or twenty largest in the land, was intimate then and is intimate now.

My knowledge of the social habits of country people was also abundant then and is still quite full. Particularly, my teaching life, extending over more than forty years, all of which brought me into constant contact with the adolescents in numbers now counting up to thousands, confirm me in my conviction. Indiscreet if not unmoral behavior was more common fifty years ago than it is today; though what exists is more frankly acknowledged now than it was then.

Let us start our consideration of the relationship between men and women with the understanding that the one state which, for adult people of sound mental and moral health, satisfies the conventions of society, the injunctions of religion and the compulsion of a sound ethical judgment, is marriage. But this does not mean that all people can be married. There are more women than there are men, in any society. If we understand the mechanism of fertilization of eggs and its relationship to sex determination, and we certainly think we do, there must be on the average practically exactly as many eggs so fertilized as to destine them for one sex as for the other. But even life within the body of the mother seems more disastrous to the male than to the female, and by the time nine months has passed, the number of girls remaining to be born is larger than that of boys. With the exception of childbirth men seem to encounter far more accidents than women. When the close of life approaches the disparity becomes greater and greater. Women outlive their husbands in considerably larger proportions than men survive their wives. So the competition between women is keener than between men.

Under the past conventions of society men can decide

their own marriage better than women. A man can invite a woman to be his wife. If she refuses, he can, and usually does, try it again elsewhere. Finally he is almost sure to succeed if he keeps up his courage. The woman is forbidden by all the conventions of society to take this part. While leap year is facetiously said to offer this privilege to her, I doubt whether in reality, the prejudices of society are any better satisfied when the girl forces conclusions in leap year than when she does so at any other time.

The girl who in her heart really decides that it is her right as well as his to take the initiative, may very often determine the whole matter. When she does so, she usually conforms to convention enough to lead the man to believe he is doing it. But it is her right, quite as much as his, and the wise young woman will recognize the fact and act on it. She is discreet under present conditions, to leave him under the impression that he is doing the choosing. A woman who wants to be, can be, in perfectly proper ways, very charming. A man who is of the right age, and of sound health, is very susceptible to charm. God made them both so and its serves His end as well as theirs. If the man does not have his affections definitely centered elsewhere, the chances are that the woman may have far more in the determination of the choice than he suspects. And, frankly, it is quite as likely to be a happy marriage under her influence as under his.

Many a man puts off marriage until delay becomes a custom and he usually does this through an entirely unwarranted fear. He sees a girl in the home of her father. The parent has been quite successful in life and has been able by this time to give his family a very comfortable

home. The young man knows he cannot give her all the luxury to which she is acustomed. He may not unreasonably hope to have equal success when he has attained her father's present age; but he does not stop to think of this. He imagines this scale of living is what she and her parents expect him to furnish. I think the father rarely does. He understands and if the young man is promising, is willing to accept him as the husband of his daughter. It seems quite more difficult for the mother to do so. Often she was more inconvenienced by the slenderness of the early income than he was. The old romantic feeling has waned. She is unwilling to have her daughter face the privations she faced. Here she is wrong. The girl herself is often not nearly so exacting as her lover and her mother think her. When romance is in her heart, as it will be if she is young enough she will see the future with expectant eye, and be quite willing to share the struggle. And she will be happy in the sharing of it if she does not constantly associate with those of more ample means than herself. When she is willing and knows he would be glad but for this fear, the girl may quite properly decide to lead him to see her attitude.

Bachelorhood and spinsterhood grow by what they feed on. When each emotional urge is smothered and repressed, after a time it finds other channels, often less discreet and always less satisfactory. After this it is easier to go on waiting. Each becomes selfishly set in his own way of living. When the time really comes at which both feel they might be married, the romantic impulse is gone. They may always be true to each other. They may try to accommodate to each other's personal habits, but the first rapture that would have been theirs

earlier will never come now. They are far more likely to adjust by each living his own life, than by either altering to meet the other.

Of course it sometimes happens that conditions absolutely prevent marriage. Whenever man or woman comes to the decision that this has happened another problem should be bravely faced at once. The sex urge is there. It always will be there. It cannot be either safely or healthfully repressed or ignored. If the man, or woman, is sensitive to the conventions, acknowledges the claim of religion and is at heart really determined to lead what is to him an honestly ethical life there is, I fear, only one proper determination and that is entire and real chastity. This is the ideal state, under the conditions. I think more people attain it than the sophisticated realize; and probably fewer do so than the unthinkingly conventional assume.

If the determination is fully made to relinquish hope of sex life, the conditions must be met, or disaster is certain. This misfortune in the first place may consist of greater or less failure to realize the ideal, with consequent impairment of self respect even when society remains too ignorant of the conditions to show its disapproval. Or, secondly the repressed urge finds its outlet in all sorts of nervous instability, which is the real trouble with the unfortunate female who is thought of as the typical old maid. Querulous, finicky, dissatisfied, meddlesome, she wants to mother circumstances and a community, without the love she would earlier have shed on her own children. That the old bachelor is less likely to become the counterpart of the old maid, and is looked on with much greater tolerance is because he rarely holds himself as conscien-

tiously to his ideal, society condoning his infractions more willingly, than it does those of his equal ineffectual sister.

Supposing then, that the one who for any reason has remained unmated has enough idealism to determine on a life of genuine chastity, the part of wisdom lies in facing the presence of the sex urge and dealing with it rationally. This can be done, and is constantly done. It is no easy task. Here is real virtue.

In the first place, it must be realized that the sex life is largely mental, and that dwelling on it in mind strengthens the urge, while keeping thought actively in other channels lengthens the interval between the impulses that will continue to arrive until late life, even in the most virtuous of single men and women.

Literature of adventure, of humor, of delicacy, of information all will help to this engrossment with other sides of life. To select for one's reading, under such circumstances the literature which describes whether it condemns or whether it condones, the infractions of this morality, is to lengthen the struggle and to make it more severe.

Enjoyment of drama must also be indulged in with similar discretion. The joyous, the gay, the tragic, all may give one the imaginative relief and enjoyment for which we go to the theatre. But sensual display and salacious dialogue, if they are ever legitimate, are terribly foolish indulgence for those of whom we are speaking.

The dance again is a problem which must be faced. This is quite independent of the question of whether this pleasure is wrong. It is full of possibilities of at least mild stimulation of the passions, which may be entirely legitimate to those whose sex relations have not yet begun but are naturally approaching in the not too distant future,

or with those who are happily or even contentedly married. Whether they are advisable to those whom we are now considering depends very much on the individuals concerned and on the type of the dance.

But even under the most careful avoidance of the stimulating aspects of life, the glands are still there and are steadily producing their hormones. These will, though perhaps at less frequent intervals as time goes, demand expression of this side of life. How shall this demand be met?

Freud and his disciples, along with much which for the public might well have remained untaught, have taught us how to answer this problem. The urge is creative. Give it some other, legitimate creative outlet.

For the man this is perhaps easier than for the woman, at least for woman as she was a little while ago. The man can throw himself strenously into his business. He can make it grow. He can make it expand. He can watch its progress as he would that of his son and daughter if he had them. Here he can safely lose himself. Then, when weariness of the nervous strain overtakes him, he can gather up his clubs or his racket and on links or court send the blood pulsing through his limbs, filling them with vigor. When entire leisure and relaxation come, literature, biography, history, science, ethics, philosophy, all can lead him on. If he can do for young folks a real service it will help wonderfully. Let him interest himself in the scouts, the hospital, in the civic chest or in anything that makes him feel that his life is not all selfish, and that he is making the world a better place in which to live. This will be satisfying even though

he is not helping to furnish the next generation that is to live in it. There are men like this; and they are a wonderful help to a community.

There is a recent type of woman who can solve her problem in exactly the same way as that described for the man. This bachelor maid lives an active business life during working hours. She plays her golf or her tennis as vigorously and regularly as the man. She runs her sport car as skillfully as he, and can serve on civic committees just as ably. She is an interesting type. We have not had her long enough to know what she will do, should she live to be old. Will her bluff break down? Will she reluctantly at last confess that a woman is not a man, and a woman cannot satisfactorily live a man's life to the end? I do not know. In any event, she is interesting while she lasts.

But the natural outlet for a woman's sublimated passions is to rear children even though they are not her own, or care for older people who are helpless. Kindergarden work is ideal. Elementary teaching does finely for many women. Vocational guidance of adolescents is a beautiful outlet if she is genuinely sympathetic and a miserable one if she cover her own loss by sniffing at their sentiment. Nursing is a noble avenue into which to guide her passion for mothering. But in every one of these the misfit is pitiful if the woman is skating along the edge of her own sex enjoyment and fighting back its open expression, dwelling on it in literature and news and scandal and shutting it out of her own activity until she is peevish and fretful and sometimes almost hysterical.

A single life may be, very often is, quite nobly and

helpfully lived. There are certainly some marriages that are much worse than single life. It is foolish to tell a girl that any marriage is better than none. But, just the same, no life has realized its finest possibilities that does not include, amongst its inmost experiences, a happy marriage and some healthy, hearty children.

CHAPTER XII

WHEN ALL GOES WELL

There is a not inconsiderable proportion of people in the world with whom "everything goes right." This does not mean for a minute that life is always smooth. It does not mean there has always, or even ever, been abundant wealth. It does not mean that there have been no difficulties, no sorrows, no sickness, no mistakes. All of these are a part of life, and no life can be entirely successful which has not had them all. But it means that there has always been strength enough to battle finally against any illness, and to come out well in the end. There has been no trial for which there has not been sufficient courage to win a triumph. There has been no mistake that was not recognized soon enough, and atoned for with sufficient earnestness and sincerity to make it reparable. Such a life is bound to be a married life and there are sure to be children. Such a life must last until the children are grown and have found their place in the world. Such a life must have won successes enough to make the late years livable without undue struggle. All of this is easily possible, and more of it lies within the power of each person to command than many people suspect. But it requires an early realization of the possibilities of such a life and an earnest determination to make every effort to attain it. The foundation of such success is laid in the preceding

generation. The boy and the girl whom we will suppose to have been the children of friendly neighbors must each have started with a reasonable heritage of health and strength. They must have grown up in a home of decent living, where father and mother treated each other with daily courtesy and in which bitter strife, at least, is unknown. These two stand much better chance of the future I have pictured if in early life, indecency, drunkenness and vice have not fallen under their childish eyes, nor lowered their standards by familiarity with them. It is hard for one to grow up to consider anything wrong which he has seen constantly in childhood.

Our boy and girl have had a frequent chance throughout childhood to get into the open air. At first this is most largely in the family groups. On holidays, or on half holidays the families have joined to spend the day out in the open, on the hillside or by the lake or stream. Enough simple lunch was taken along to satisfy the eager appetites and not a little of it needed preparation over a wood fire, confined in a broken circle of piled stones. The boys and girls of the party learned to run, to climb, to row a boat and paddle a canoe, to swim and to dive, and they all grew up doing these things together. They saw enough of each other's bodies in ordinary play to be entirely used to the sight. An occasional unexpected intrusion or untoward accident had left nothing entirely to the imagination.

There came a time with the oncoming of adolescence when the older children began to separate themselves a little from the younger, and amongst the older boys and girls there was a large care to avoid intrusion. As time went on the boys learned to guard the girls against dis-

comfort, and the girls to rely on the boys for such chivalry.

When high school days came, the boys and girls came to have a much wider circle of acquaintance. They soon learned that by no means the same standards prevailed. The girls soon found that not all boys are chivalrous. The boys soon found that not all girls demand chivalry. But the fine play our friends had had with each other left no doubt in the minds of either of them. The girl often put up with boys who were not so chivalrous. Sometimes she rather enjoyed the departure. But it did not take her long to learn that a boy of that sort goes about as far as the girl will let him. She on her side soon learns to decide on just where that point is, and fortunately for her, decided that it came pretty early in the game. But the one thing she learned best of all was that with her old friend she had nothing to fear. She saw it was not because he liked her less, but because he liked her more.

On the boy's part he soon found petting an enjoyable pastime, and was quite inclined to start it easily with almost any nice girl friends. With some of them he found he could go much farther than with others without offending them at all. Now and then he started the game with his old playmate but he found that he really did not want to be as familiar with her as he had been with some of her more willing companions. Instinctively he felt that he was cheapening her, and this he had every impulse not to do.

When, in these two families, the younger children were born, the intimacy of the family life had been sufficient to make the event not unexpected in either case. When each of our friends had come to an understanding age, father in one family, mother in the other had had wisdom

and information enough to tell the whole story of the sex life. In both cases the teaching had gone far enough to make our children realize that children should only come with the blessing of God, and of society, in marriage.

In the class in biology in the high school they gained the first real scientific understanding of reproduction. With it was joined the teaching that sexual intercourse could only be properly indulged in by those who were married, not only because of the precepts of religion, but because society treated with scorn those who infringed, making life very hard, especially for the girl. They were made to realize that the child of such a union, when there was one, and this is quite possible in spite of effort to the contrary, is horribly handicapped, especially if it be a girl, by the lack of social standing society puts upon it. This is all wrong, of course. There can be no blame to the child of such a union. Whatever punishment society inflicts should be absolutely confined to the parents. They have done all the wrong there may be in the case. But society has not realized its injustice as yet.

It was after they both got to college that the biology teacher went quite beyond his science. He made the boys and girls feel that a genuinely carried out plan of the union of one man and one woman, under the sanction of law, religion, and convention, was the triumph attained only after ages of struggle, and not yet fully attained.

He showed them that promiscuity was a drop back in the scale towards lower animal forms, was behaving like dogs and rabbits, instead of like twentieth century humans of the type leading the advance. The class had been interested before. They went out from their lessons with a new seriousness. Some of them laughed it off and

went on just as before. But most of them, including our two, held to their seriousness. The petting grew less frequent, and the limit was set far earlier. Another influence came about this time. The dean of women, giving our girl permission to go with a boy friend for a sleigh ride said to her, "I think, if I were you, I would not permit any treatment presuming affection, which did not have back of it all the affection it presumed. To permit more might be fun now but it will forestall a much deeper joy which will come from the same treatment later on when the boy who gives it is really dear to you."

Our girl's musings before the sorority fireplace when she sat there after coming in from a social evening and before going to her room, had been turning toward her old playmate, and somehow he always compared well with anyone else she went out with.

The boy had a more serious shock. He had found a sprightly girl in the town who was jolly and sociable and who had no hesitancies about abundant and rather familiar petting. The attraction of it was drawing him on. He was enjoying it tremendously. But when he sat before the fire and began to dream of her he found himself rather despising not her, but himself. He realized that when he was with her he was certainly not at his best. One night a fraternity brother, finding him before the fire, put an arm over his shoulder and said, "I don't want to butt in, but you seem to be getting pretty friendly with somebody I want to tell you about. I met her last year. I went pretty fast and she went with me. One night we lost ourselves, or perhaps I had better say I lost myself. I have a splendid girl at home. She is all a man can want, I want to marry her when I get through college. It is a bitter

question whether I will by then have entirely recovered from a disease I caught that night. I would rather never marry my girl than give her that disease, or than see it come out in my children." He dropped his arm, and passed upstairs. Our boy sat still for a long time. He went up to his room after awhile, with the first real touch of the "world pain" on his heart. His prayer that night was short but it was the most earnest he had ever prayed. "Oh! God, help me keep myself clean."

Each of our friends had a touch of a "crush" with one and another of their companions, and each after a time realized that it meant nothing.

It was Junior Prom that wakened them both. He led her aside after a dance, and without a word kissed her, and she without a word yielded to his kiss. Each knew that kiss meant more than any either had given before.

When Senior year came they were acknowledged sweethearts. It is true some of their branches of study had been neglected. This is particularly apt to be the case in a coeducational college. But they had found each other, they had led clean lives, they had built the foundation for a happiness worth far more to them than any class standing could possibly be.

When the boy got his first position, and had held it long enough to be sure it was his, he asked her for the formal engagement and she wore his ring—showing it first of all to her mother.

He and she talked over the matter fully and decided to be married in six months. His income was not large enough. though it promised to grow steadily. She had become a stenographer. She asked her employer whether she might continue in her place for a time if she were

married and he replied "Just as long as you do good work and come regularly, and your husband is willing to have you do it."

Her mother tried to dissuade her and to have her wait, but she said "No, my lover is too fine for me to disappoint. But mother, I do not want an unexpected child to spoil the program. I want children when we can afford to have them. But I want my husband now, while we are full of love and of high purpose." She found it harder than she expected to learn wise methods of birth control, but she persisted. Finally she found one of her schoolmates of an upper class who had married two years earlier and was very happy. This woman proved a Godsend to her.

She not only told her what she wanted to know in that matter but gave the excellent advice that experience had taught her, and that would have relieved her of much misunderstanding and discomfort during the first days of the honeymoon had some good friend told her before. Then came her crowning good advice. "Don't ever let yourself think that you are lowering yourself in any way when you give yourself to your husband. If he is true to you, and you are true to him, you will find that your physical relations, instead of being a yielding to a lower nature are the basis of an abiding affection, an esteem, that will bind you ever closer and fill the home with a glow that makes it the one spot on earth for you and for him."

It was not long before another step was to be taken. There were two incomes. What should be done? They pooled them. Each had a checking privilege. It was agreed upon that he would attend to the rent, taxes, insurance and fuel. She would use a definite sum for running

the home including such service as her work outside made it necessary she should employ. The balance was divided into three parts. He had one part for his personal expenses, she one for hers, the rest went into a savings account.

When they divided their income in this way there was little for savings at first, but they stuck to it. While they denied themselves much they would have liked, they lacked nothing they absolutely needed.

When his salary grew, the time came when she could afford to give herself to the home alone. She dispensed with all but occasional service. He did not a little to help her. Again the finances needed adjustment. Just as before, he paid certain things, certain other expenses were hers. But now, on each pay day he gave her a check for her "salary." He found it meant ever so much more to them to call it this than to call it allowance. This she deposited in her own name, and out of it paid her share of the living expenses, and the rest was her own savings.

They found that when she was so much about the home and by no means so tired as she had been while doing office work, that a new honeymoon came on and then happiness was deeper than ever before. Once someone threw in a doubt and suggested the possibility of excess. After a few days question in his own mind he frankly went to his father and asked about the possibilities. This elder man was wise enough to counsel them well. "While you and your wife love each other thoroughly, all day long, when you wake loving as you went to sleep loving, when you go with vigor to your morning's work and she goes with spirit to the care of the home have no fear." And they had none.

Years have gone. The children they wanted came. These grew up and are now placed in life. The children always had their mother's care. She never neglected them. But she never forgot the father of these children, nor made him feel that a new interest had eclipsed him in her heart. They are well on in years. Their modest home is their own and fits them well. Their children come back often to the home they all love. But life is still sweet to them both. They can still sit in the gloaming and their petting is now one of the sweet delights of life—for they have earned it.

INDEX

† Indicates a picture.